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ELECTRICAL COMMUNICATION BETWEEN LIGHT VESSELS & SHORE.

IT is to be hoped that the singularly inconclusive report just made by the Committee appointed by the Board of Trade to consider the desirability of electrically connecting light vessels and lighthouses with the shore, will not lead to the entire abandonment of the project with which it deals. Without doubt the comparatively heavy cost which would be involved is a formidable obstacle in the way of any extended adoption of electrical communication round the coast, but it should scarcely have been allowed by the Committee to surmount every other consideration in their minds and make them timorous of acknowledging the absolute utility of the scheme if carried into effect. "Without denying the very general proposition," says the report, "that all communication with lightships or lighthouses which would tend to the saving of life at sea would be desirable, your committee feel that their decision must evidently depend upon other considerations, very mainly upon that of cost, and, bearing that important element in mind, we are of opinion that the immediate extension of the system is not desirable." This is rather a startling statement: a little firmer expression of opinion in favour of the "very general proposition" would have been warranted by the minutes of evidence taken before the committee, but at any rate there is the seemingly half-reluctant acknowledgment that a beneficent and useful purpose might be served, and to say that this is the side of the question which, above all other sides, must not be regarded as being of any prime importance, is to convert the whole enquiry at once into a monstrous absurdity.

Fortunately the report does not end there. Further clauses run thus: "We consider that the experiment carried on at the *Sunk* lightship has not been sufficiently long on trial for us to say that there is not still much to learn. We have also been informed that electrical communication with another lightship, at the entrance to the Mersey, is likely to be established before long by the Mersey Docks and Harbour Board. We therefore beg to recommend to your lordship that a final decision should be postponed, and that the experiment at the *Sunk* lightship should be continued for a further period of 18 months. With regard to the question of establishing electrical communication with outlying lighthouses and islands, we are of opinion that if Her Majesty's Government would introduce, and carry through Parliament, the Bill for the acquisition by Lloyd's of sites for signal stations, many of the difficulties brought before us would be removed, and we therefore recommend this step to the favourable consideration of your lordship." If these recommendations are acted upon it will at least be something to be thankful for. It would not have been very surprising if it had been asserted as an argument against the continuance of the experiment at the *Sunk*, that during the 12 months that vessel has been connected with the shore at Walton not a single occasion has arisen for the use of the cable as a means of saving life or of bringing assistance to a wreck quicker than it would otherwise have been brought: such arguments have not unfrequently been used when it has been desired to depreciate the importance of an innovation, and its introduction in the report under notice would not have been inconsistent with the logic of the statement of which we have already spoken; but a crushing blow was dealt by the Hon. H. W. Chetwynd, R.N., to any inclination which might have existed to put this view forward, that gentleman, who is the Chief Inspector to the Lifeboat Institution, pointing out that a similar argument would apply to many lifeboats, which sometimes go ten or twelve years without doing a service, and then are able suddenly to render very valuable service indeed. This is the view which should be taken of this question of electrical communication. There is undoubted evidence of the fact that wrecks often occur under such conditions that the ordinary means of signalling to the shore are of no avail whatever in preventing loss of life. Perusal of the evidence of Captain Thomas Emerson, the Hon. H. W. Chetwynd and other witnesses will impress this very strongly upon the most doubting mind. This being the case, and it being admitted that a readier and more definite means of conveying intelligence to the shore, such as would be afforded by electrical communication, would in many cases answer the purpose of bringing succour to the spot with sufficient promptness, the whole position in favour of the desirability of the electric cable seems firmly established. That the system should be complete and exhaustive at the outset no one will have the hardihood to contend. A gradual adoption and extension of the system is the plan which most readily commends itself, and a beginning might well be made by connecting several of the light vessels on the treacherous Goodwin Sands.

Sir James Douglas gave very valuable evidence of a practical character in this connection. An important point to be borne in mind which he insisted upon is, that the ship with which the experiments have hitherto been made is not of a type to give the best results; he contends for a heavier vessel of a slightly different type, costing about £10,000, and requiring about £1,570 per annum for maintenance. The difficulties of maintaining the cables in efficient working order, great as they must be in the exceptionally trying localities where, usually, lightships are established, Sir James Douglas thought might be got over; even in the case of detached lighthouses, which, established on rocky bottoms, offer the greatest obstacles to successful cable laying and maintenance, he said it was mainly a question of money, for he did not know a single instance in which it would be impossible. The one only objection which Sir James appeared to have to electrical communication was of rather a curious nature; knowing the mercan-

tile marine and the masters of it well, he believed that the temptation to a master to communicate with his wife earlier or later than he could otherwise do would be sufficient sometimes to induce him to risk the lives of passengers and crew by approaching too closely dangerous spots upon which lighthouses are situated. Three men extra would, in his view, be required to attend to the telegraphic duties; and other witnesses doubted whether the capacity of many lighthouses was sufficient to accommodate the extra men and the necessary apparatus, whilst it was also thought that the telegraphists would possibly impede the lighthouse men in the execution of their duties. If a system were once inaugurated, however, all difficulties of this kind would quickly be eliminated.

Upon the whole, we cannot see that there is any insurmountable difficulty in the way of a gradual establishment of a system of some kind whereby information of the whereabouts, character, and condition of a wrecked ship might with certainty be conveyed instantaneously to shore. The cost undoubtedly would be heavy, and we can only say, whilst reiterating that the expenditure might be made the more tolerable by being spread over a period, that this is one of those directions in which the outlay of large sums would be amply repaid by the services to humanity which the system would be capable of rendering.

THE HEXTHORPE RAILWAY ACCIDENT.

THE terrible railway accident which occurred at Hexthorpe, near Doncaster, on Friday the 16th inst., the closing day of the Doncaster race meeting, is one of those events which come home to the hearts of all. Since the Tay Bridge and Pennistone mishaps nothing so terrible in the loss of, and injury to life has occurred. Twenty-four killed and some fifty-seven injured is a casualty list happily not often to be found in the railway annals of this country. In commenting upon the Report of the Board of Trade upon the past year's railway accidents in our issue of the 9th inst. we were gratified to find ourselves in a position to speak favourably of the statistics there given. That a great improvement has been effected in the safe conduct of railway traffic of late years no one can doubt. The report referred to shows that during the year eight passengers only were killed by what may be regarded as train accidents, and those occurred during the first half of the year. The returns just published for the first half of the present year also show that no passenger life was lost from the same cause. We have thus twelve months during which the railway traffic of the country was carried on without sacrifice of life to any one passenger from a train accident. Such a result brings the unfortunate Hexthorpe collision before us all the more forcibly, reminding us how easily and, possibly, with how slight an oversight, a moment's forgetfulness, or a moment's want of watchfulness, a terrible tale may have to be told; and above and beyond all this, indicating with all imaginable force the fact that the dread power for producing such calamities, in spite of the advances and improvements which have been effected, continues not only to exist, but is, with the increasing demand of the day, ever on the increase; and that it is only by perpetual foresight, watchfulness, and care, as well as by the employment of the most complete devices for checking and meeting the erring human mind—too often by constant repetition of work reduced to a mere machine—that those great forces are to be kept within such control as shall prevent catastrophe.

The site of the Hexthorpe accident, as most of our readers will have learnt from our daily contemporaries, is a point some 800 yards on the Doncaster side of Hexthorpe Junction, and distant some mile and-a-half from the Doncaster station. The line forms a portion of the Manchester, Sheffield and Lincolnshire system, and is worked ordinarily under the block, but during race times, in order to get the traffic through, the block is suspended at Hexthorpe Junction, and trains are worked by what is known as hand signalling; that is by men posted along the line within sight of one another, who bring the trains on by flags or lamps, the red flag or red light being danger and the green flag or green light proceed with caution. Into this section a Midland train had entered and was drawn up at the ticket platform—used only on race occasions—for the collection of tickets. It is stated that not only were the signals at Hexthorpe Junction at danger while the train was standing there for this purpose, but that the ground signallers were showing red flags, when a M. S. & L. train from Liverpool came into collision with it, with the lamentable result already indicated.

It is by no means our desire to in any way prejudge the case. The engine driver has reserved his defence—we think very judiciously. He is a man whom it is said bears an excellent character, and has some 16 years' experience as an engine driver. The block was suspended and the ground covered by hand signallers. The signals are said to have stood in the face of the driver. Such a method of working congested traffic is by no means uncommon, but it will be evident that whenever adopted it requires—for the reason that it supersedes a far different mode of working—to be very carefully hemmed in with additional precautions. For the present we withhold further remarks, but we shall return to the subject on the conclusion of the enquiry, which will be instituted ere these lines are in print.

INSTANCES of generous enthusiasm in a trading company are not numerous, but the Telegraph Construction and Maintenance Company fairly earns our admiration by its determined prosecution of the costly experiments in effecting electrical communication with the *Sunk* lightship. This work was begun under contract, but it soon became evident that the amount for which the company had undertaken to make and maintain the connection was utterly inadequate. Unforeseen circumstances arose to add largely to its expensiveness, yet the company persevered, and succeeded in proving the feasibility of electrically connecting a light-vessel with the shore, a feat of which many people doubted the possibility. The contract has involved a direct

loss to the company of about £2,000, but it is to be hoped that a reward will be forthcoming for such plucky and disinterested perseverance.

THE current meter of Prof. George Forbes, F.R.S., which we illustrate this week, and upon which an interesting discussion, which we report for the benefit of our readers, took place at the recent British Association meeting, is destined to fill an important position in the future of electric lighting, if all its inventor claims for it is capable of performance. A large market already exists for the instrument—not in this country, it is true, but in America—and we wish Prof. Forbes, who is about to proceed to New York to show the meter at the Electrical Exhibition and to read a paper upon it before the National Electric Light Association, every success with his promising offspring. As described, it stands as the simplest and most accurate for continuous currents and as absolutely the only one for alternate currents. The day seems still far distant when there will be any extensive demand for a current meter in England, but when it does arise we may expect to find Prof. Forbes's meter, perfected by use, ready to discharge the duties for which it is designed.

THE rapidity with which the editions of the Phœnix Fire Office rules for electric light installations follow one another is a little bewildering. Not very long ago we noticed the issue of the ninth edition; now we are informed that the whole of that large edition has been exhausted and that a tenth has been issued. There is no doubt about the efficacy of these rules; if there is any criticism at all to be passed upon them it is that they err on the side of strictness, and even that may be regarded rather as a commendation than otherwise; that they answer their purpose is testified by the fact that where they have been adopted not a single fire has occurred. Their value has been recognised abroad as well as in this country, and they have been translated into various foreign languages, besides which some thousands of copies have been sold in the colonies and in the United States.

QUITE an animated little correspondence has been proceeding in the *Times* upon the subject of lightning conductors. Prof. Tyndall wrote from the mountain fastnesses of Switzerland to the leading journal to state his opinion that a great deal of ignorance prevails as to the real requirements in a lightning conductor system. Lord Grimthorpe followed this with an exposition of his views and a description of the methods adopted in a church with which he is connected. The curious course of taking the rod down on the inside of the building was there followed, and earth connection made by driving an iron crowbar deep down into the ground. Prof. Silvanus Thompson conceived the idea that Lord Grimthorpe had driven his bar into a solid rock, and promptly pointed out the danger of such a proceeding. The noble lord was a little sarcastic in his reply, explaining that the object of driving the bar into the ground was to find moisture, and that, as it penetrated deeper, according to his view, than an iron plate, a more effective earth connection was made in that way. With all deference to his lordship, we are inclined to think his plan is not necessarily the safer one. In many instances a very much longer bar than would be likely to be used would be necessary to reach damp earth, and there is usually no reason why a plate should not be placed at as great a depth as could be attained by a bar. Moreover, the greater surface contact brought about by the use of the plate facilitates dissipation in comparatively dry ground much more readily than the pointed bar. Other letters than these we have mentioned have appeared in the *Times*, amongst them one by Mr. G. J. Symons, who was secretary of the Lightning Rod Conference, and who complained of the neglect with which the report of that conference has been treated. It is almost too much, perhaps, to expect that the public should take the pains to gain all the information which is to be had upon a technical subject of this kind, but it is most decidedly to be expected—in fact, to be insisted upon—that architects in particular, and, after them, those having the responsible charge of public and other lofty buildings, should make themselves thoroughly familiar with the requisite means for protection from lightning. Nowhere will more trustworthy information be found than in the report of the Lightning Rod Conference, which we commend to the notice of that large part of the community embraced in the comprehensive phrase "all whom it may concern."

THE end of "the present relations" between Great Britain and China is threatened. At least so says Count Mitkiewicz, who is supposed to be the prime mover in the matter of the Chinese telephone concession to an American syndicate. At the same time that it may actually be the fact that Great Britain is in a comparative sense losing ground from a commercial point of view in China, we are inclined to think that it will take more than a single piece of sharp business practice to oust the British altogether from the market places of China, and to close the field of enterprise against them finally and irretrievably. There is no very definite information as to the exact character of the negotiations which have taken place between the Chinese authorities and the representatives of the American Syndicate, and it is more than probable that the reports which have appeared have been greatly exaggerated. The incident should, however, arouse the enterprise of this country to recognition of the unequalled opportunities which exist in China for operations of various kinds on a grand scale, and of the significant fact that our great rivals of the future are making strenuous efforts to get a foothold in that wonderful but undeveloped country. It would be a strange contradiction of the instincts of human nature if the Chinese had conceived an intense affection for the Americans; and so far as racial antagonism is likely to have any influence our dear cousins have a great deal of prejudice, more or less justified, to get over. The syndicate now at work, however, are nothing if not bold and sanguine, and, in the words of the New York correspondent of the *Standard*, they look beyond banks and telephones to a commercial union between China and the United States. That is scarcely within the range of practical politics just at present; but, we repeat, it behoves England to look to her laurels. Some mention has been made of threatened legal procoedings to restrain the syndicate from using telephones in China, but what this may mean is not very comprehensible, for China has no patent laws.

THE literature of secondary batteries is not likely to be greatly enriched by anything which was brought before the B.A. meeting. The paper read by Mr. Killingworth Hedges is not without a certain degree of interest, but the main facts therein stated may nearly all be found, together with an illustration of M. Bailly's cell, in a previous number of the REVIEW.

THE ROYAL JUBILEE EXHIBITION, MANCHESTER.

GENERAL ELECTRICAL EXHIBITS.

HAVING in previous articles described the lighting arrangements of this Exhibition and the several exhibits in connection with that subject, there remains now but to give some description of the various electrical apparatus and applications of electricity, which are to be met with in the different sections of the Exhibition, and although the number of exhibitors is not so great as might have been expected, there are many objects of very great interest which require attention.

The Manchester Electric Supply Company, Limited, exhibits, with Messrs. Crossley Brothers, Limited, several complete sets of electric lighting plant suitable for private houses. On Stand 484 the dynamo and gas engine for each set of plant are mounted on the same foundation; a very compact combination, perfect steadiness in work being secured by means of a novel and ingenious arrangement of driving gear. The apparatus exhibited is suitable for the supply of houses requiring from 20 to 60 incandescent lamps. The dynamo can be used with or without accumulators, a set of the latter are exhibited together with a complete switchboard, fitted with Holmes and Vaudrey's patent automatic cut-out, by means of which the cells on the starting or stopping of the gas engine, are connected or disconnected automatically to or from the dynamo without requiring any attention from the attendant. At Stand 484*a* a comprehensive assortment of electric light fittings as manufactured by the company for use in factories, mills, offices, private houses, &c., are shown. They also exhibit sectional switches, fusible cut-outs, measuring instruments for current and for electromotive force.

At Stand 575 Messrs. W. H. Bailey & Co. show their patent "wire tester"—Government pattern. In testing wire by this machine the tensile strength is indicated by means of the dead weight of a column of mercury, which remains fixed in position. When the specimen is broken the column of mercury is slowly permitted to go back to zero, when a small back-pressure valve is lifted from its seat. Some important improvements have been made in this instrument at the suggestion of Prof. Unwin.

At Stand 619 the Electric Portable Battery and Gas Lighting Company, Limited, shows a very large and interesting collection of electrical instruments and appliances, consisting of various forms of their patent dynamo-electric gas lighters, electric bells and gongs, batteries of all kinds, indicators and pushes, induction and medical coils, model electric bath for medical purposes, and various other items.

At stand 364, Mr. H. Bury, of Manchester, shows a very prettily arranged installation of incandescent lights supplied from his new form of dynamo, having an output of 80 lights, to which we have already alluded. The arrangement enables a variety of switches to be brought into play. The stand is constructed in the form of a dome, the lights being suspended from the top on silk flexible pendants, while on one side a neatly mounted table with top piece is fixed, upon which are some very handsome brass brackets with lamps, and in the centre, a polished mahogany switchboard, in which is fixed a variety of switches, fusible cut-outs, &c., for controlling the lights. Mr. Bury also exhibits the "Upward primary battery," which is utilised for lighting some lamps.

At stand 384, Messrs. Mather and Platt, to whom we have already alluded in previous notices, show their patent electric cloth "singeing" machine for removing the nap from silk, cotton, and linen cloths and other fabrics. This consists of a frame provided as in the ordinary plate-singeing stove, with entering rails, draw rollers, water box and wince, driven by a small independent engine or from shafting, or (as may in some cases be convenient) by a small electro-motor. But in place of the copper plates or row of gas burners, the singeing is effected by three (or less) thin platinum bars or plates carried in special fire bricks, which diminish the conduction of heat from the bars to the cast iron channel in which the bricks are held. The plates are heated to a bright red heat by the passage of an electric current produced by a dynamo machine. The dynamo at the exhibition used for heating the platinum strips is of the Edison-Hopkinson type with an output of 55 volts and 288 ampères driven from the shafting in the annexe. The cloth is pressed down upon the plates by two bars under which it passes, the pressure being regulated by a suitable lever, placed in a convenient position at one side of the machine. There is also an arrangement for quickly lifting the cloth from the plates in case of stoppage. The temperature of the plates is regulated by varying the intensity of the magnetic field of the dynamo, which is readily done by inserting resistance in the magnet circuit. A switch controlling this resistance is placed on one side of the machine, or in any position which may be found most convenient. The power required for driving the dynamo is proportional to the heat generated in the bars, and the current can be instantaneously cut off, and no power absorbed, immediately the batch of cloth has passed. In order to bring a fresh part of the glowing surface of the plates continuously into contact with the cloth, a rocking motion through a small arc is imparted to them from the driving gear of the machine. In this exhibit the gear is connected by chain with a small 5 H.P. "Manchester" dynamo motor. There are many advantages claimed for this singeing machine, the most important being that it is always ready for use, and that the time taken to bring the bars to the requisite heat is so short that operations can be commenced in less than half a minute, comparing most favourably with the two other methods of singeing by gas flame and by copper plates The temperature of the plates and the width required to be heated can be regulated easily, and the same heat can be maintained for an indefinite period. Besides other advantages, such as cleanliness and absence of offensive products of combustion, it must be borne in mind that the dynamo used for heating the bars can, when the machine is not running, be utilised for electric lighting, so that a double purpose is served. The questions of economy and efficiency we are unable to speak about, as beyond seeing the plates brought to the requisite heat we have been unable to see the machine at its proper work. At the same stand Messrs. Mather and Platt show a ten-colour calico printing machine, to which we have alluded in a previous number.

At stand 402 the Anglo-American Brush Electric Light Corporation shows a dynamo worked by friction gear lighting up some arc and also incandescent lamps, also a small dynamo driven by a direct acting high-speed engine (Raworth's) actuating a small "Victoria" motor, which is utilised in driving a pump. At the same stand are shown a ship switchboard and various electric light fittings.

Amongst the handicrafts at 1,131, the Self-Winding and Synchronising Clock Company, Limited, shows clocks wound by electric motors and synchronised by the electric current.

Messrs. Charles L. Baker & Co., of the Cornbrook Telegraph Works, exhibit at stand 604 a collection of electric light fittings with Browett's patent switch, electric bells and indicators with various forms of alarms, testing and railway telegraph instruments, lightning conductor fittings, and a large variety of philosophical apparatus, amongst which we noticed a Wimshurst influence machine. Amongst the above may be seen a very neat and portable set of testing apparatus, consisting of a portable astatic galvanometer having a resistance of 600 ohms, and a Wheatstone bridge, the capacity of the apparatus allowing of tests being taken ranging from 0·1 ohm to 1,100 ohms. These instruments are constructed at a price which places them within the reach of students, amateurs, electric bell fitters, and lightning conductor men, and of many others who require to take tests and measurements. The various exhibits are excellent for the manner of construction and quality of finish, and in the latest electrical industry—that of electric lighting

—a very large assortment of switches and other fittings are shown, but we must draw attention to the fine examples of switch-boards manufactured by this firm and used in the incandescent electric lighting of the exhibition, which may be seen in the dynamo room. These switchboards are 52 inches by 36 inches, and are mounted on slate fixed on mahogany boards. One is used in connection with the circuits to the Fine Arts Galleries controlling 1,620 incandescent lamps, and the other controls the lamps in the dining rooms and in Old Manchester and Salford as well as a number of other branch circuits. To each circuit are attached special automatic cut-outs to prevent the circuits being overloaded. The switchboard, by means of sliding bars, regulates three circuits, and in addition a spare dynamo enabling changes to be made. A Cardew voltmeter is attached to the switchboard, and by means of a sliding contact the E.M.F. of each of the circuits can be readily tested. As the length of the mains is very great and a considerable loss of potential takes place in the circuit, it is very essential that frequent observations of the E.M.F. at the dynamos should be observed, and the sliding connection enables this to be done very rapidly. These switchboards reflect the highest credit upon Messrs. Charles Baker & Co., for the excellence of the work and the completeness of the details and finish, and they form an interesting and striking feature as an important adjunct to the successful lighting of this exhibition. In the "shooting lodge" installation in the grounds, there is another switchboard manufactured by this firm, but this we have described in a previous article.

In the Irish Section at 1,194, Mr. William Henry Elliott, of Thurles, shows some interesting models of electric appliances for repeating the actions of points and signals ; at 1,211 the Belfast Electric Appliances Company shows arc light carbons and lamps, and at 1,221 Messrs. Yeates & Sons, of Dublin, exhibit several electrical apparatus, and Sir Howard Grubb, F.R.S., in his observatory (1,234) brings electricity into use for purposes of astronomical observation.

In the Chemical Section the committee of the section exhibit at No. 716 in a darkened room a collection of revolving Geissler tubes, which attract a great deal of attention amongst the public, and are viewed with astonishment by the uninitiated Lancashire visitors. In this section also will be found one exhibit of very great interest, as it foreshadows very strongly an application of electricity in the future to the dyeing of textile fabrics. This is described under No. 779, "Select Exhibit of Committee of Section III. Collected by J. J. Hummel, Yorkshire College. Series of patterns of cotton and silk dyed with coal-tar colours obtained by means of electricity. (Lent by Prof. Dr. Goppelscroeder.) Apparatus to show the production of aniline black on cotton, discharge white on indigo blue, &c., by means of electricity. (Lent by Prof. Dr. Goppelscroeder.)" The samples shown are very beautiful, as exhibiting the excellence of the colour obtained by electrical dyeing, and they are the results of many years' investigations and experiments by Dr. Goppelscroeder. The apparatus used consists practically of a Bain chemical telegraph arrangement, such as will be found described in Culley's Hand-book of Telegraphy. It is arranged for writing on chemically prepared cloth with a pen, the current being supplied from a small set of accumulators. These accumulators are charged daily from the dynamo room, from which place a wire is brought close to the stand. The exhibit is of very great interest, and is deserving of serious attention, as the time cannot be far distant when electrolysis will play a very important part in the question of dyeing fabrics.

Submarine Telephony.—A good word for the telephone was said by Sir James Douglas in his evidence before the Electrical Communication with Lightships' Committee. He said the telephone had worked admirably on the *Sunk* cable (which is $8\frac{5}{10}$th miles in length), and had exceeded the expectations of all experienced men. He preferred it to the A. B. C. telegraph.

ON THE THEORY OF THE DYNAMO.

By O. FRÖLICH.

(*Concluded from page* 283.)

DEPENDENCE OF THE CONSTANTS UPON THE POSITION OF THE COMMUTATOR.

In order to decide what influence the position of the commutator exerts upon the value of the constants of the machine, the curves of polar tension without exterior resistance for various positions of the commutator were drawn for a Siemens and Halske machine, *c* F_s, with cast iron limbs. Fig. 11 shows the results (P_∞ ordinates, *v* abscissæ), the curves A, B, C, D correspond respectively to the positions of the brushes 0°, 11°, 22·5°, 34°, reckoning from the verticals ; 22·5° is about the proper position of the commutator at which the fewest sparks appear.

The observations were as follows :—

	v :	600	700	800	900	1,000	1,100
P_∞	A :	4·65	7·72	20·2	30·8	41·1	50·3
	B :	4·66	13·0	30·7	41·6	52·0	62·7
	C :	6·87	14·6	32·2	42·7	52·8	63·4
	D :	6·54	12·2	28·3	40·3	50·8	60·7

The curves are essentially parallel straight lines ; a lingering of the polar tension at low speeds always occurs with machines of this kind on working with an increasing speed.

As constants were found

	f	P_∞
A	0·102	61·2
B	0·104	52·0
C	0·103	50·5
D	0·104	53·6

The armature constant remains therefore unaltered at different positions of the commutator, whilst the constant of the limbs varies considerably, and is smallest at the best position of the commutator.

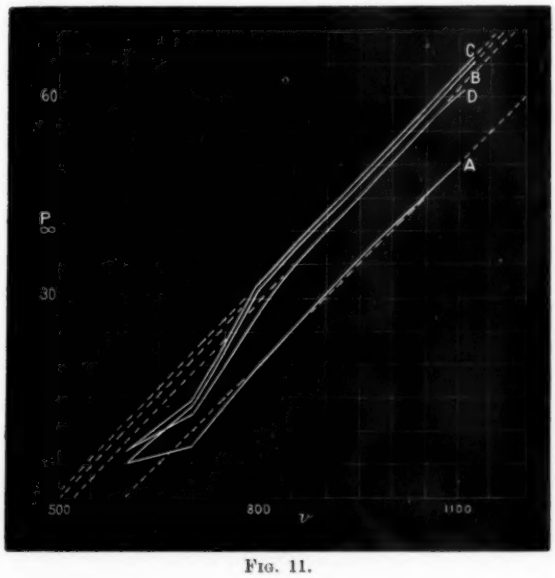


FIG. 11.

It would be interesting to know whether this behaviour occurs in other machines.

ON THE MEASURE OF THE MAGNETISM.

Silvanus Thompson, Von Waltenhofen and Dietrich have objected to the introduction of the relative magnetism or the degree of saturation as found in my latest memoirs and in my book, and seem to assume that in my earlier representation only the absolute magnetism was employed, and only the relative magnetism in my present writings.

In order to clear away this misunderstanding it must be remembered that I formerly wrote:

$$\frac{E}{v} = \frac{J}{a + b \cdot J}.$$

But now:

$$\frac{E}{v} = \frac{1}{b} \cdot \frac{\frac{b}{a} \cdot J}{1 + \frac{b}{a} \cdot J}$$

$$= f \cdot \frac{\mu \cdot m \cdot J}{1 + \mu \cdot m \cdot J} = f \cdot M,$$

whence, therefore,

$$f = \frac{1}{b}, \ \mu \cdot m = \frac{b}{a}, \ M = \frac{\mu \cdot m \cdot J}{1 + \mu \cdot m \cdot J},$$

in which f or $\frac{1}{b}$ is the maximum of the magnetism.

The formula, therefore, is not altered, but only so divided that both the absolute maximum of the magnetism and the relative magnetism or the degree of saturation become prominent; according to the earlier way of writing we have only the absolute magnetism referring to a certain strength of current.

The recent manner of writing gives, therefore, not merely the relative but the absolute magnetism, and in a form which does not depend upon the value of the strength of the current; I have repeatedly found in my experience that the introduction of the relative magnetism is of practical value and gives a view of the behaviour of the machine, which without this introduction would remain hidden.

If we find in an early machine with little iron in the limbs and much copper on the armature, that the relative magnetism fluctuates between 60 and 80 per cent. of the maximum, whilst in a more recent machine with much iron in the limbs and little copper on the armature it varies between 30 and 50 per cent., these figures already convey a decision on the behaviour and the value of the machines which cannot be supplied by anything else.

I must adhere to the endeavours to calculate absolute magnetism in absolute measurement, and to introduce the density of the lines of force, and I shall in future recalculate the constants of the armature accordingly.

FINAL REMARKS.

I may be permitted to express my opinion on the present position of the theory of dynamo machines.

In consequence of the researches of Hopkinson and Kapp, the question concerning the properties of the characteristic has entered upon a quite new stage. We can only look upon these attempts with sympathy and expect with interest their further development. If I am not mistaken Hopkinson's method will grow into an exact and comprehensive treatment of the subject, but being too circumstantial it remains without any important influence upon practical purposes. Kapp's method will, perhaps, not become accurate, but if it permits of calculation of the iron substances beforehand, even in an approximate manner it will become of great practical service on account of its simplicity.

But I wish to call attention to the fact that most English and French writers favour the view that the entire question is solved when we have drawn and explained the characteristic. One consequence of this opinion is that in England and France observations such as every practical man makes almost daily on his machines, are neither published nor discussed as they are to a very considerable extent in Germany.

I have repeatedly expressed my opinion to the effect hat the characteristic forms only the beginning and not the end of a judicious theoretical representation, and that the graphic methods herewith connected solve only single practical questions, but not all, and do not afford a deeper insight into the behavour of the machine.

I should like here to propose to the "knights of the characteristic" a problem which corresponds to the daily needs of present practice, and upon which the value of the different methods of treatment may be most plainly exemplified, namely:—

Given on a machine with a purely shunt circuit coiling and a decidedly demagnetising action of the armature currents, a number of experiments with different exterior resistances and speeds; required to determine the electric behaviour of the machine in such a manner that any desired practical questions may be solved easily and with sufficient accuracy, and that we may obtain an insight into the properties of the machine.

This problem has been solved by myself and others according to my representation, for an entire series of quite different machines. If another way of treatment as simple and suitable can be found, I shall readily withdraw my representation from public discussion. If this is not the case, the inference is that my representation is the most suitable for practical purposes.

SELF-INDUCTION AND ITS MEASUREMENT.

By E. C. RIMINGTON.

(*Continued from page* 281.)

Suppose in a circuit, through which passes an alternating current, we have two coils of respective resistances and coefficients of self-induction, R_1, R_2, and L_1, L_2, placed in parallel; and it is required to substitute for these two coils one coil such that the total current, and its retardation, shall be unaltered by the substitution. The following solution is due to Dr. R. M. Walmsley.

Suppose the main circuit, which contains the source of the alternating E.M.F. to have its resistance and coefficient of self-induction zero. Writing for brevity $S = \sqrt{R^2 + a^2 L^2}$, we have:

$$i_1 = \frac{E_0}{S_1} \sin (a t - \phi_1)$$

$$i_2 = \frac{E_0}{S_2} \sin (a t - \phi_2)$$

$$i_0 = \frac{E_0}{S_0} \sin (a t - \phi_0)$$

Where i_0 is the main current, S_0 the apparent resistance of the two coils in parallel, and ϕ_0 the angle of retardation of the main current.

Now $$i_0 = i_1 + i_2$$

$$\frac{\sin (a t - \phi_0)}{S_0} = \frac{\sin (a t - \phi_1)}{S_1} + \frac{\sin (a t - \phi_2)}{S_2} \quad (1)$$

Also

$$\tan \phi_1 = a \frac{L_1}{R_1}; \ \tan \phi_2 = a \frac{L_2}{R_2}; \ \tan \phi_0 = a \frac{L_0}{R_0};$$

since $E_0 \sin a t$ will be the potential difference at the ends of each coil.

Whence

$$\sin \phi_1 = \frac{\frac{a L_1}{R_1}}{\sqrt{1 + \frac{a^2 L_1^2}{R_1^2}}} = \frac{a L_1}{\sqrt{R_1^2 + a^2 L_1^2}} = a \frac{L_1}{S_1};$$

$$\sin \phi_2 = a \cdot \frac{L_2}{S_2}; \ \sin \phi_0 = a \frac{L_0}{S_0}.$$

Similarly

$$\cos \phi_1 = a \cdot \frac{R_1}{S_1}; \ \cos \phi_2 = a \cdot \frac{R_2}{S_2}; \ \cos \phi_0 = a \cdot \frac{R_0}{S_0}$$

Let $a t = 0$; then (1) becomes

$$\frac{\sin\phi_0}{S_0} = \frac{\sin\phi_1}{S_1} + \frac{\sin\phi_2}{S_2}$$

$$\frac{L_0}{S_0^2} = \frac{L_1}{S_1^2} + \frac{L_2}{S_2^2} = Q \text{ suppose} \qquad (2)$$

Again let $a\,t = \frac{\pi}{2}$; then (1) becomes

$$\frac{\cos\phi_0}{S_0} = \frac{\cos\phi_1}{S_1} + \frac{\cos\phi_2}{S_2}$$

$$\frac{R_0}{S_0^2} = \frac{R_1}{S_1^2} + \frac{R_2}{S_2^2} = P \text{ suppose} \qquad (3)$$

Rewriting (2) and (3) we have

$$\frac{L_0}{R_0^2 + a^2 L_0^2} = Q \text{ and } \frac{R_0}{R_0^2 + a^2 L_0^2} = P.$$

Solving these two equations for L_0 and R_0 we obtain

$$L_0 = \frac{Q}{P^2 + a^2 Q^2} \text{ and } R_0 = \frac{P}{P^2 + a^2 Q^2}.$$

But P and Q are known in terms of the resistances and coefficients of self-induction of the two branches from (2) and (3). This form of the solution, as will be easily seen, readily permits of its extension to the case of more coils than two in parallel. From the above result we may find the angle of retardation for two coils in parallel if we know the angles of retardation for each coil, thus :—

$$\tan\phi_0 = a\,\frac{L_0}{R_0} = a\frac{Q}{P} = a\,\frac{L_1 S_2^2 + L_2 S_1^2}{R_1 S_2^2 + R_2 S_1^2}$$

$$= a\,\frac{L_1 (R_2^2 + a^2 L_2^2) + L_2 (R_1 + a^2 L_1^2)}{R_1 (R_2^2 + a^2 L_2^2) + R_2 (R_1^2 + a^2 L_1^2)}$$

Now

$$L_1 = \frac{R_1}{a}\tan\phi_1 \quad \text{and} \quad L_2 = \frac{R_2}{a}\tan\phi_2$$

Therefore

$$\tan\phi_0 = \frac{R_2\tan\phi_1(1+\tan^2\phi_2) + R_1\tan\phi_2(1+\tan^2\phi_1)}{R_1(1+\tan^2\phi_2) + R_2(1+\tan^2\phi_1)}$$

If the two coils are in series ;

$$\tan\phi_0 = a\frac{(L_1 + L_2)}{R_1 + R_2}$$

$$= \frac{R_1\tan\phi_1 + R_2\tan\phi_2}{R_1 + R_2}$$

Methods of Measuring the Coeffieient of Self-Induction.

It is necessary to be able to practically determine the value of L for any given coil or circuit. These methods may be divided into two classes :—

(1). Methods of finding L by measuring a time and a resistance.

(2). Methods of comparing L with the capacity of a condenser.

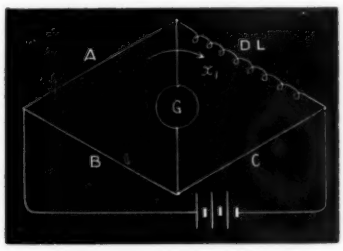
In class 1 there are Rayleigh's method, Ayrton and Perry's, Mascart and Joubert's, and Thompson's modification of the latter.

In class 2, Maxwell's method, and the author's modification of the same.

Rayleigh's Method.

In an ordinary Wheatstone bridge, let the arm, D, consist of the coil or circuit whose coefficient of self-induction is to be measured, let its value be L. Let the other arms, A, B, and C possess no self-induction. There is a key in the battery branch, and also one in the galvanometer branch. The galvanometer must be a ballistic one.

First obtain an ordinary balance by depressing the battery key before that of the galvanometer; then A C = B D. Now close the galvanometer key before the battery key, and the effect of the self-induction in D will be to give a throw on the galvanometer, which must be observed; let its value be δ. On releasing the battery key an equal throw will be obtained in the opposite direction.



Let us consider the current through the galvanometer at some instant, t, after the battery key has been released. The E.M.F. acting in D, due to self-induction, is $L\frac{dx}{dt}$; where x is the current in D at the instant, t.

Now by the laws of shunts, the current in G

$$= \frac{L\frac{dx}{dt}}{C + D + \frac{G(A+B)}{G+A+B}} \times \frac{A+B}{G+A+B}$$

$$= p\,L\frac{dx}{dt}$$

where $p = \dfrac{1}{C + D + \frac{G(A+B)}{G+A+B}} \times \dfrac{A+B}{G+A+B}$

Therefore the quantity passing through the galvanometer or

$$Q = p\,L\int_0^\infty \frac{dx}{dt}\cdot dt = p\,L\int_0^{x_1} dx = p\,L\,x_1$$

x_1 being the permanent current flowing through D when the battery key is down.

Now insert a resistance, r, into the arm, D, so as to destroy the balance, and give a permanent deflection, θ, in the galvanometer. This will, of course, alter the current in D, let its value become x_2.

Then the current through the galvanometer or

$$g = \frac{r\,x_2}{C + D + \frac{G(A+B)}{G+A+B}} \times \frac{A+B}{G+A+B}$$

$$= p\,r\,x_2$$

Consequently $$\frac{Q}{g} = \frac{L}{r}\cdot\frac{x_1}{x_2}$$

or $$L = r\cdot\frac{Q}{g}\cdot\frac{x_2}{x_1}$$

Now since G is a ballistic galvanometer,

$$Q = \gamma\cdot\frac{P}{\pi}\cdot\sin.\frac{\delta}{2};$$

where P is the period of the needle, and γ is the reduction factor, when the instrument is treated as working like a tangent galvanometer, *i.e.*, when the deflection is small.

Now if θ be small, $g = \gamma\tan\theta$.

Therefore $$\frac{Q}{g} = \frac{P}{\pi}\cdot\frac{\sin\frac{\delta}{2}}{\tan\theta}$$

Hence $$L = r\cdot\frac{P}{\pi}\cdot\frac{\sin\frac{\delta}{2}}{\tan\theta}\cdot\frac{x_2}{x_1}$$

* *Vide* ELECTRICAL REVIEW, Vol. XX., page 373.

If a reflecting galvanometer be employed, as would be nearly always the case, since δ and θ will both be very small angles, we may replace sin $\frac{\delta}{2}$ by $\frac{\delta}{2}$ and tan θ by θ, and write

$$L = r \cdot \frac{P}{2\pi} \cdot \frac{\delta}{\theta} \cdot \frac{x_2}{x_1}$$

Now $\frac{\delta}{\theta} = \frac{d_1}{d_2}$ very nearly, where d_1 is the throw in scale divisions produced by the self-induction, and d_2 the permanent deflection in scale divisions, due to want of balance.

So

$$L = r \cdot \frac{P}{2\pi} \cdot \frac{d_1}{d_2} \cdot \frac{x_2}{x_1}$$

(To be continued.)

SKETCH OF THE PRINCIPAL ELECTRICAL PAPERS READ BEFORE SECTION A DURING THE LATE MEETING OF THE BRITISH ASSOCIATION AT MANCHESTER, 1887.

By Prof. OLIVER J. LODGE, D.Sc., F.R.S.

IT may serve a useful purpose, and be not uninteresting in itself, to pass rapidly under review some of the communications made to the Physical Section of the British Association at its recent sitting, to sketch what appear to be the main objects of each paper, and to indicate as far as one can its net result. In attempting this it must be apparent that such a sketchy account cannot avoid being meagre and in many respects unsatisfactory ; but inasmuch as sooner or later the publication of each paper will take place, and the complete views and intentions of the author can then be appreciated, no harm will be done by a partial and crude preliminary abstract.

The simplest order in which to quote the papers will be that in which they were read.

Immediately after the President's address on Thursday, Prof. Schuster described his new experiments on the electric discharge in vacuum tubes. He finds that if a discharge be sent through air rarefied to a pressure of a millimetre of mercury or thereabouts, the whole of the air in the vessel becomes conducting ; so that, for instance, a gold leaf electroscope inside the vessel is unable to retain the slightest charge while the discharge is passing, and a single cell battery is able to propel through several inches of air a steady current capable of deflecting a galvanometer perceptibly. And this happens whether the discharge be a continuous one as from a powerful battery, or an intermittent one as from a common induction coil. Moreover, it happens when the discharge region is partitioned off by a good electrostatic screen from the region of the gold leaves or weak battery circuit terminals. All that is necessary is that the partition shall not be a complete one in the mechanical sense, it must permit the passage of *air* round or under or through it, but it may be as complete in the electrical sense as a sphere of fine wire gauze or as a plate of sheet metal.

The meaning of the experiment is believed by Dr. Schuster to be that the air is dissociated by the discharge into atoms respectively oppositely charged, and that these charged atoms wandering about are able to convey a current of electricity between electrodes exactly as they are supposed to do in the case of an ordinary liquid electrolyte.

Anyone who is not familiar with the appearance of a continuous battery current through a vacuum would be much struck with the beauty of this form of the experiment.*

Later in the day Prof. Horace Lamb hastily gave the gist of a paper on a subject which has an electric as well as a hydrodynamic bearing. When water or other fluid flows through a tube, it is well-known that the stream is most rapid at the axis of the tube, where it is freest, and most retarded near the walls of the tube. This is a natural result of friction and fluid viscosity. But the question arises whether the layer of fluid which actually touches the wall of the tube moves at all, or whether it clings so tightly as to be actually and completely stationary. Certainly water adheres to glass with considerable force ; the inside water is sheared along the outside water, but is the outside water sheared along the glass ? is there, in fact, any "finite slip" ? The simplest and ordinary procedure in hydrodynamics is to assume none : to treat the outermost layer of water as stationary. But now comes in the electrical contribution to the subject. Prof. Wiedemann and others have observed that an electric current sent through a tube of liquid tends to propel that liquid bodily along the tube. This is called electrical endosmose. Prof. Quincke, on the other hand, has observed the converse phenomenon, viz., the fact that if a current of water be driven mechanically along a tube, its two ends acquire different potentials and can deflect an electrometer. Both these effects have been explained by Prof. von Helmholtz as due to a contact electromotive force between the water, on the one hand, and the glass of the tube—or, at any rate, an outer skin of water *affected by* the glass of the tube—on the other : the water becoming, say positive, and the glass negative—like most other things when put into contact. If now the two ends of the tube be kept at different potentials, it is very natural that the water (being already slightly electrified by contact) should be driven along the tube, being propelled, in fact, by its own skin. The effect, however, is excessively small and can hardly be observed in a wide tube. A capillary tube, or better still, the interstices of a porous partition are the best for showing it and making it conspicuous.

The converse effect is likewise easily explicable, for when water is driven along a tube the finite slip occurring at the boundary acts like any other frictional machine and produces ordinary electrification. The only reason why the observable effects are so small is because water is a conductor, and the electricity leaks back along it almost as fast as it is produced. Fine tubes, therefore, do better than coarse, and alcohol or other bad-conducting liquid would do better than water.

But Helmholtz, instead of thus simply and naturally assuming a considerable finite slip between water and glass, apparently felt impelled to try whether the effect could not be produced without such an hypothesis, to which many facts seemed contrary. He, therefore, assumes that the outer layer of water divides itself into two—an "electrical double layer" as he calls it—between the components of which a contact difference of potential exists ; and he then supposes that the outermost skin of this double layer clings fixedly to the glass of the tube, by the contact of which its properties are modified, and that the inner skin slides over it. He thus calculates out the experimental laws of the phenomena, and finds numbers agreeing with observation. Probably he was driven to this seemingly forced hypothesis, of the modified and unmodified water layer, and the sliding of one over

* There is just one point on which the views of the author are not clear to the present writer, viz., where Dr. Schuster considers the fact that he can drive a current through air by means of an E.M.F. of one-fourth or one-tenth of a volt as being itself a proof that there is no important difference of potential between the metal of his electrodes and the air. Seeing that any step of potential up from metal to air at one electrode must be precisely counterbalanced by an equal step down at the other electrode, I do not see how the fact that you can easily drive a current from one to the other proves anything.

If the two electrodes were of different metals, say one zinc and the other platinum, and if it were found equally easy to propel a current either way between these, then something extraordinary could be deduced ; but no doubt such an arrangement would act as a simple battery. So long as the two electrodes are identical, even though they be both zinc, I fail to see how their behaviour can prove anything about difference of potential between metal and air ; though at the same time, so long as platinum or oxidised aluminium is used, I am very willing to admit that the actual difference of potential is most likely minute.

the other, by finding the amount of slip necessary to explain the effects greater than could reasonably be assumed between water and glass.

Now comes in Prof. Lamb's modification. He has gone over Helmholtz's work point by point, and sees reason for differing from him with regard to some of the molecular magnitudes involved. He introduces into the formula a new factor having 10^{-8} in its denominator. The result is, that although he also requires a finite slip to explain electric endosmose and its converse phenomenon, yet he makes a very much less slip sufficient; so that he is able to return to the simple and natural view that the outer layer of water actually slides on the glass, but that an almost infinitesimal slide is all that is wanted to explain electric endosmose. He thus to all intents and purposes confirms the old view of the scientific hydraulic engineer, that the outermost layer or skin of water is practically stationary. Professor Lamb's paper is ordered to be printed *in extenso* among the reports, and it will be then easier to appreciate the exact modification introduced by his theory, which at present is, of course, *sub judice*.

Immediately after this paper occurred the event of the meeting, the thing for which in all future times the visit of the Association to Manchester will probably be famous. Not that it made any sensation at the time; it scarcely took up 10 minutes of the time of the section; the President made no remark upon it, and only by two or three individuals who happened to have been thinking in the same direction was its real significance understood. It was a short paper by Sir William Thomson, entitled, "On the Vortex-Theory of the Luminiferous Ether." To understand the meaning of it one must go back a little.

It is well-known that several years ago Sir William Thomson suggested a vortex theory of matter, based on the observed behaviour of a vortex ring and on the properties of vortices in general, as investigated mathematically by Helmholtz. The "vortex-atom," as it is called, is a favourite subject of speculation, and Prof. J. J. Thomson is attacking the problems of chemical combination by its means. But although this remarkable theory of the nature of matter was before the world, and its consequences being traced, yet of the nature of the ether we had no such theory. It was perceived that many of the properties of the ether must be those of a perfect fluid, else how could planetary bodies move unresistedly through it? But, on the other hand, some of its properties must be those of a solid, else were it incapable of transmitting waves of light. It was likened, therefore, to a jelly, and to pitch, which in some respects are semi-fluid, in others semi-solid; it was pointed out that bullets could sink through apparently solid pitch if time enough were given them; and the difference between this slow creep and the rush of a planet was asserted to be only one of degree. Yet this was felt to be not quite satisfactory, and the contradictory properties possessed by the ether remained paradoxical.

Then Prof. FitzGerald, of Dublin, made a brilliant guess: the properties of the ether could only be explained, he conjectured, by an assemblage of minute vortices in a perfect fluid—a "vortex sponge," as Sir William Thomson had previously called such a structure. If the ether consisted of a perfect fluid, everywhere completely enwrapped in utterly minute vortices, much more minute than the comparatively gross vortex rings constituting the atoms of matter, then would it permit the passage of bodies through it with perfect ease. It would also act as an electric and magnetic medium in the way needed by the Faraday-Maxwell theory; and in all probability, so he surmised, it would be found capable of transmitting the transverse waves of light. But to prove this last property deductively from the theory of vortices seemed a task of supreme difficulty, from which he shrank.

Actuated possibly by this suggestion, perhaps quite independently of it, it must have occurred to Sir William Thomson to consider this problem as a mathematical exercitation during some hours of leisure. However it happened, he did consider it, and did solve it; apparently, too, without very much difficulty, or much consciousness of the feat he had achieved. At Manchester he scribbled the proof in a few lines on the black-board: and it was thenceforth known that a vortex sponge of perfect fluid could do everything that the luminiferous ether was known to do. Among the audience was Prof. W. M. Hicks, who probably knows as much of vortex mathematics as any man living, and he expressed himself afterwards as fully satisfied with the proof, and conscious of the greatness of the discovery.

Prof. FitzGerald, in proposing afterwards at the committee meeting that the paper be printed *in extenso* among the reports, characterised it as the greatest step towards the comprehension of the intrinsic structure of the universe which had been made since the time of Newton; the only possible exception occurring to him being the vortex theory of matter itself.

It is perhaps rash to wax enthusiastic over the greatness of an infant at the moment of birth: a man must commonly live, and must die, before his right magnitude becomes really known; nevertheless, when a discovery has been watched and hoped for, it is surely not only natural but seemly to herald its advent in not too dull and prosaic a manner.

It is not to be supposed that the discovery is complete and finished; a great deal more remains to be done to get it into shape and work it out, but a splendid start has been given.

Thus much for the results of Thursday. Passing on now to the next day, we come first to the new electric measuring instruments of Sir William Thomson.

The idea of these is to do away with all alterable opposition forces, such as permanent magnets and torsion or other springs afford, and to balance the attracting power of a current by the dependable force of gravity itself. The attraction between two pair of coils is in fact weighed, and hence all possibility of variation in the constant of the instrument is avoided. If once correct, it remains correct until it becomes damaged or broken. It is set right first by a voltametric silver determination, and ever afterwards it serves as a standard of current, and, with certain reservations, of E.M.F. also. A beautiful series of instruments for different purposes was shown; whether they are not too delicate for workshop use remained doubtful; but as they are certain to be speedily depicted and described in every electro-technical journal,* it is needless to dwell on them further.

There is one point of special practical interest in their construction, viz., the means adopted for conveying a powerful current to the balance arm without friction or much rigidity. This is effected by means of a pair of thin flat bands or combs composed of a multitude of very thin copper wires suspending the balance arm.

Mr. Glazebrook's optical report, and other optical papers, followed, but though optics is at the present day becoming but a branch of electricity, yet this view of it is hardly yet fashionable, nor are electricians generally so interested in the nature of Light as doubtless by next century they will become.

Towards the end of the sitting Prof. Ewing described his recent remarkable researches in magnetism.

It is perhaps known that the Ampère-Weber-Maxwell theory of magnetism requires that for some very high magnetising forces the magnetisation produced shall cease to increase and begin to diminish; in other words, that the susceptibility of a substance to magnetism shall decrease and even become negative for sufficiently high magnetising force. Thus, then, iron, if enormously over-magnetised, might actually become diamagnetic like bismuth.

To verify this prediction, the writer of this article has himself made some attempts, and is able to show a

* Sir William Thomson's instruments were fully described and illustrated in the REVIEW for May 27th and June 10th, 1887.—EDS. ELEC. REV.

body which is paramagnetic in a weak field and diamagnetic in a strong one; but then such a body is not simple, pure, and homogeneous, it is purposely built up of a magnetic and a diamagnetic substance. Or even when not purposely built up, who is to say that some trace of impurity is not at the bottom of the phenomenon?

Professor Ewing has proceeded in a different way. He has pushed the magnetism of iron far beyond hitherto recorded limits, and believes that he finds indications that the decrease of susceptibility has begun. Whether this be so or not, there is no doubt of the tremendous magnetic inductions he has obtained. On the same scale as that on which the earth's horizontal intensity is ·18 units, Professor Rowland of Baltimore had obtained a field in iron as high as 25,000 units; and had given reasons for believing that this was about the maximum possible. Afterwards, Prof. Ewing managed to get it up to 32,000; and now, with the great magnet of Edinburgh University excited by a storage battery, putting a sharply sloped double-coned piece of Lowmoor iron with very narrow neck between its large poles, he has succeeded in beating his own record and forcing the magnetic induction in iron up to 45,350. Cast iron has gone up to 31,270; and even in air he has measured a field of 25,620 units.

Prof. Ewing and Mr. Low, and on another day Prof. Barrett also, described further experiments on the peculiar 12 per cent. manganese steel, which is scarcely more susceptible to magnetism than is zinc. They find indeed that its magnetic permeability is only half as great again as air, and that accordingly it may become very useful for ships's plates and for the bedplates of dynamos.

On Saturday Sections A and B sat together for the consideration of electrolytic and electro-chemical subjects. The papers read will most of them shortly appear in these pages, and a brief general review is all that seems necessary.

After a report had been read, Prof. FitzGerald and Mr. Trouton gave a further statement of their experiments as to the exactness with which electrolytic conduction obeys Ohm's law.

They have been greatly troubled by temperature difficulties, which in liquids are far more accentuated than in metals, for reasons which Prof. FitzGerald clearly explained.

They succeeded, however, in proving that if there were any deviation from Ohm's law in copper sulphate solution it must be less than 1 part in a hundred thousand; a very satisfactory and valuable result. But whether this statement will apply equally well to very pure water or other bad conductor is still, strictly speaking, an open question.

Dr. S. P. Thompson communicated a paper by Prof. von Helmholtz on the effect of pressure on the electrolysis of water. Helmholtz gives a formula whereby the change of E.M.F. needed to decompose water under any pressure, produced by any gas or mixture of gases, could be calculated, so long as those gases reasonably obeyed Boyle's law. By experiment this formula was verified for very low pressures, with at any rate fair accuracy; and the result was that whereas 1·7 volts were necessary to the decomposition of water with platinum electrodes at atmospheric pressure, ·17 volt more would be required at 1,000 atmospheres, and ·17 volt less would be sufficient at the one thousandth of an atmosphere. Pressure of the liquid's own vapour need not be reckoned. Whether the solubility of gases was taken into account or not I am not sure; I incline to think not; and if so the calculated results for high pressures are less likely to be accurate than those for low. Moreover, at very high pressures the mixed gases are apt to spontaneously explode.

Prof. Roberts-Austen then described his experiments on the passage of a current of several hundred ampères through a fused alloy of gold and lead, and of silver and lead, to see if any decomposition whatever could be detected. Assaying to within one part in 10,000 he could detect no difference; thus proving that, for these alloys at least, the conduction is wholly and simply metallic.

Prof. Lodge made an interim report on the experiments which he and Mr. E. E. Robinson are carrying on with regard to the rate at which the ions travel in electrolysis. He experimentally proves that in such a solution as salt and water containing one-tenth of a gramme equivalent, or 5·8 grammes, of common salt per litre, the hydrogen atoms move at the rate of ·0029 centimetres a second; that is 10½ centimetres, or about 4 inches an hour; when urged by a slope of potential of 1 volt per centimetre, that is 30 volts applied to the ends of a tube 1 foot long.

Prof. Rowland then described some remarkable experiments, made partly by himself partly by others, on chemical action in a magnetic field. It is found that if a piece of intensely magnetised iron is being dissolved, say in nitric acid, the parts most strongly magnetised are half protected, and are consumed less rapidly than other portions. Points and edges, for instance, are in this protected condition; hollows and flat places go first. It may be expected, therefore, that highly magnetised iron shall be somewhat electro-negative to ordinary iron, so that if the two be immersed in any corrosive fluid and joined to a galvanometer they shall act as a feeble battery and give a current. This also is found true.

It is plain that in dissolving and removing iron from a highly magnetised pole a little more work has to be done than if it were not magnetised; and therefore the protective tendency of magnetisation is to be expected. The only question was whether iron *in solution* would be sufficiently attracted to cause a perceptible effect. Some time back the writer of this article made somewhat similar experiments on magnetised and unmagnetised iron immersed in ferrous sulphate, using an arrangement very like that described by Prof. Rowland, though without so clearly perceiving the efficacy of points; the idea was to get a current by pulling iron out of solution with a magnetic pole. But oxidation of the ferrous sulphate by air caused a lot of trouble from spurious currents, and with insufficient perseverance the attempt was abandoned. It does not follow that it would have been successful, because this idea of the protection of iron from corrosion, though based on the same principle, is different in detail.

Dr. Gladstone gave an account of some experiments on the effect of passing an electric current through solutions in which a chemical precipitate is slowly forming. It is well known that the formation of a lagging precipitate can be hastened either by heat or by shaking. Dr. Gladstone now finds that the passage of an electric current has a similar and marked effect. This also is an interesting result; showing that electrolytic conduction assists the interchanges or double decompositions occuring between mixed compounds.

Messrs. Gee, Holden, and Lees, brought forward some laborious experiments on the effect of pressure on the electrolysis of water and on the electromotive force of polarisation. They worked at very high pressures, and were met with the difficulty of spontaneous combustion of the mixed gases. It must be remembered that this recombination need not necessarily occur in free space. It is known to occur easily in the presence of platinum, and there is no reason to suppose other solids incapable of bringing it about in the films condensed on their surfaces, especially at pressures of 300 atmospheres or so.

Prof. Silvanus Thompson explained the conditions under which *brass* can be electro-deposited, and showed how any desired proportion of copper and zinc can be obtained. The important points to keep sight of, in understanding how an electro-positive metal like zinc comes to be deposited at all in presence of copper, are the enfeeblement of the solution near the cathode plate, and the effect of this on the E.M.F. necessary for deposition of any particular metal. He also exhibited results of the commercial electro-deposition of good metallic *platinum*, which if non-porous is likely to be extremely useful.

Mr. W. N. Shaw gave the gist of a long and elabo-

rate paper by Mr. FitzPatrick on the effect of the solvent in electrolytic conduction. It appears that whereas methyl alcohol by itself conducts better than does pure water, yet a solution of salt in methyl alcohol conducts distinctly worse than the corresponding aqueous solution—a singular and interesting result.

Monday was divided between meteorology and pure mathematics, but on Tuesday some more electrical papers were taken.

Professor Quincke described his observations on the behaviour of gases immersed in a strong magnetic field. He takes a glass tube, closed by a sensitive pressure gauge, and fills it with the gas to be examined, sometimes at high pressure. He then immerses it in a very powerful magnetic field, and reads the gauge with a microscope. He thus finds that the magnetic stress in the gas is accompanied by a slight increase of pressure, amounting in some cases to as much as 5 millimetres of water. He gives, as the formula for the increase of pressure,

$$p' - p = \frac{\mu H^2}{8\pi};$$

where H is the strength of the field, and μ the magnetic permeability of the gas; and so makes it analagous to the effect caused by an electrostatic stress. The measurements of μ thus obtained by Quincke agree very fairly with those of Faraday—"Exp. Res.," III., p. 502.

Mr. Glazebrook reported on the construction of standards of electrical units, and stated that the B.A. unit coils had not varied perceptibly among themselves since Mr. Hockin examined them 15 years ago; and since they are made of several different materials, the probability is very great that they have not varied at all.

Prof. Rowland gave the final result of the elaborate series of determinations of the value of the ohm standards which he has been carrying out for the past few years under the auspices of the American Government. His value in ohms of the old B.A. unit agrees almost precisely with that found by Lord Rayleigh; but his determination of the column of mercury representing one ohm shows a discrepancy which, though small, is nevertheless large considering the care taken and the comparative simplicity of the operation.

Mr. Glazebrook adduced evidence showing that M. Mascart's mercury standards had varied from the time they were made to the time they were tested at Cambridge and retested again in France; and the feeling of the meeting plainly was that some explanation of the outstanding discrepancy between Prof. Rowland's and Lord Rayleigh's mercury determinations would probably be forthcoming after Prof. Rowland had returned to America and overhauled his tubes.

The correspondence between the ohm determinations at Cambridge and at Baltimore was so close as to be matter for congratulation, considering the extreme difficulty of the measurements and the difference of methods employed.

Prof. Ewing and Mr. Low described some interesting observations on the effect of a cut across a bar of iron on the magnetism developed in it by a given magnetising force. The bar was made part of a complete magnetic circuit and wrapped with a certain number of ampère turns; and then measurements were taken of the number of lines of force passing through it, first when entire, next when cut once through, then with two, three, and ultimately seven cuts, so that the bar became a column of eight pieces piled on one another. Not only was the bar tried thus but pressure was brought to bear upon it so as to cause better contact over the cut faces, and to show the effect of this. The cuts were first made carefully in the lathe: later they were also highly polished and made true Whitworth planes. Briefly it may be said that whereas each cut very distinctly weakens the magnetic induction, diminishing the permeability of the bar, pressure assists to restore some of it again; although it acts in a double fashion: squeezed *iron* being less permeable, while a squeezed *joint* is more permeable than an unsqueezed.

The Whitworth plane faces, however, enabled pressure to bring the bars so well into contact that they practically became whole again, and the cut had then no effect—at least so long as the pressure lasted.

On the whole, Prof. Ewing believed the effects of the cut to be completely accounted for by the presence of air films some thirtieth of a millimetre thick between the faces; nothing more occult being needed to explain the defect of permeability. But as Sir William Thomson urged, it would be well to repeat with a film of gold leaf before being absolutely sure of this result.

The remaining papers were not of high scientific importance, though doubtless of some general and technical interest. There was a curiously rudimentary, not to say trivial, paper by Sir William Thomson on Poggendorff's method of measuring electromotive force, as given in any text-book, except that one of his current weighers is used instead of a tangent galvanometer. Mr. Preece related the continuation of his large scale experiments on induction between wires, which the resources at his command render possible. Prof. Forbes exhibited his ingenious smoke-jack coulombmeter, which acts both as a tell-tale of how much current is being used and as a record of how much has been used, whether said current be alternating or steady. Mr. Swinburne explained how he proposed to eliminate temperature errors from galvanometer and other such coils, by winding them with two opposition coils of unequal strength and different temperature-co-efficients, so proportioned as to produce compensation on the gridiron-pendulum principle; and Dr. Edward Hopkinson summarised in a complete and comprehensive form the general theory of dynamos, up to which he has been working for the past few years, both in conjunction with his brother and by his own practical experience. This paper is in type and does not lend itself to further abbreviation. Suffice it to say that it marks a distant stage of progress in the history of the science to be able to treat the phenomena of magneto-electric induction in this general and satisfactory manner.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

(Specially Reported for the "Electrical Review.")

AN ELECTRIC CURRENT METER.

By Prof. GEORGE FORBES, F.R.S.

(Section G.—Mechanical Science.—September 5th, 1887.)

[This paper appeared in the REVIEW for September 9th.]

DISCUSSION.

The CHAIRMAN (Sir Frederick Bramwell): The Board of Trade unit is what this meter shows. Really it is perfectly surprising to think within how few years that which was merely an experiment of the lecture room has become a commercial matter to be dealt with commercially. We have here a most simple form of instrument which lends itself to the recording of the quantity of electricity used when alternating currents are employed—a difficult problem which, as Prof. Forbes has told us, his instrument, as simple in construction as a smoke jack, has solved. It really is a smoke jack over electric power.

Sir WM. THOMSON: I have very great pleasure indeed in congratulating Prof. Forbes. Everyone who knows anything about electric lighting understands perfectly that the want of a meter is one of the greatest practical wants in connection with the introduction of central station lighting. I speak feelingly on the subject, for I have tried year after year to produce a meter. There is nothing to which I have given up so much time in endeavouring to make an instrument work as in endeavouring to produce an electric meter, and the Patent Office contains records of some of my attempts. Each one of them has been to some degree capable of giving a result, and the last of them, which I worked at a very great deal till four months ago, promised considerable accuracy and was perfectly available for either direct or alternate currents. But the difficulty of seeing a way to bring this instrument out and to make it a practical thing, at a moderate cost, for general use, was so great that I do not feel that I intend to go on with it at all. It is just possible that I might make it succeed as a meter for a large station. But I am exceedingly glad to see the great success which Prof. Forbes has obtained. I think I may say I

am untinged with any feeling of regret at its having been done by another. On the contrary, it is with the most unmixed feelings that I say I am exceedingly glad, and that Prof. Forbes is to be congratulated. With respect to one scientific point raised by what Prof. Forbes has said, we must not be too confident of escaping absolutely, in an alternate current meter, the effect of different speeds of the engine. Every kind of measurer of alternate currents is affected by different speeds of the engine. In my alternate balance for alternate currents I found it necessary to divide the conductor into thin wires insulated from each other by cotton or silk in order to compel the current to be distributed through the different parts of the conductor equally. In a meter founded upon alteration of temperature, a similar effect would hold. If in a thick copper or iron strip, such as would be used by Prof. Forbes with high currents, the self-induction acts so as to sensibly impede the current—if the impedance by self-induction is comparable with the impedance by resistance, then Prof. Forbes will be subject to the same difficulty as others. Still I think that in his case the difficulty of practically avoiding effects of self-induction will be much less than in any instrument founded on magnetic force. I am glad to find that Prof. Forbes has with so simple an instrument obtained so perfect a solution of the problem as the numbers he has placed before us prove, and congratulate him most heartily on the result.

Prof. PERRY: One has no right to ask an inventor of such a beautiful instrument as this by what means he arrived at the idea embodied in it. I could not have imagined that he could have got this result. The figure certainly shows that it is a beautifully simple instrument and effects its purpose well. But how anyone could arrive at such a method from any theoretical information passes my understanding. The whole action seems to be so complicated. I do not think I should have tried it if the idea had come into my head. I suppose one must miss a tremendous lot of valuable things in this way, because one does not see the theory. It is a marvellous thing. I certainly think it is one of the most beautiful things we have had before us for a long time. I speak now as an inventor of a meter which is in considerable practical use, not in this country, unfortunately, where it is patented, but in Germany. That is also a very simple one, but I think that this beats it.

Prof. SILVANUS THOMPSON: As another who has tried the invention of a meter, I feel disposed to congratulate Prof. Forbes most heartily on this extremely beautiful and simple solution of the difficulty. I only wish to ask one question, and that is whether this meter, in integrating the various quantities that pass through it, integrates the mean square of the current or the square root of the mean square.

Mr. A. P. TROTTER: May I ask if the size of the cover has any effect upon the speed of the rotation. Starting with the air cold it gets warm with the current, and then has to be cooled in order that the rotation may be kept up. I would also ask, what is the difference of speed when the clockwork is put out of gear? That is to say, how much work is absorbed in turning the clockwork, which is the only work it has to do, I suppose.

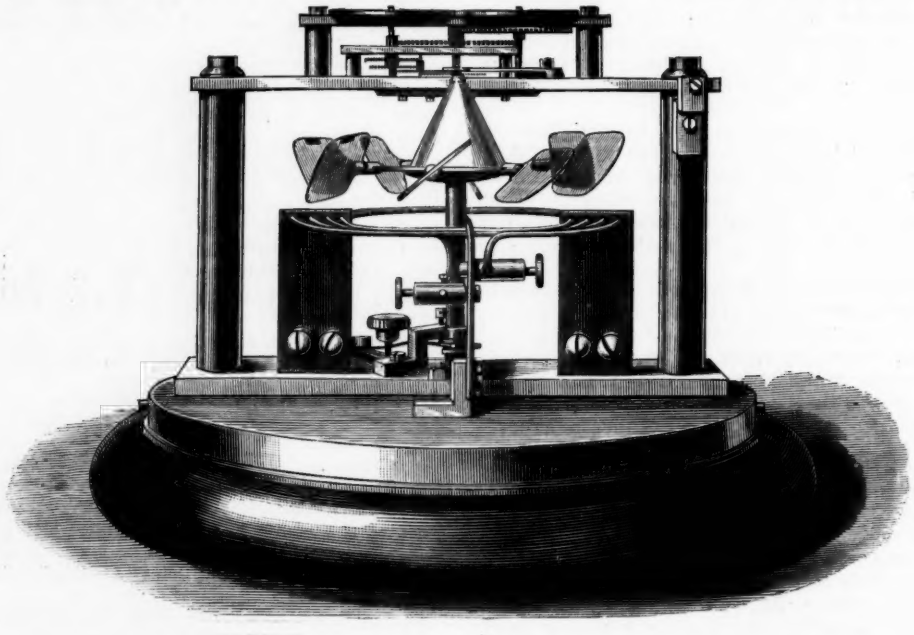
Mr. R. P. SELLON: I should like to ask Prof. Forbes if he has tried the difference of rotation in the veins—the difference in the speed of indication for a given current when the air in the chamber is at atmospheric temperature, and, again, when the meter has been run for some time, as it appears to me that possibly even a small amount of heat given off from the heated wire may after a certain length of time raise the temperature of the whole of the air within the chamber.

Mr. F. R. UPTON: At what percentage of the rated capacity of the meter does it start? That is, after standing for some time. I should also like to ask, if the clockwork which the meter is now turning is without oil and running dry, how much retardation that would cause upon the meter.

Mr. LAW asked whether the speed of the meter was affected by the external temperature of the atmosphere.

Prof. BLYTH asked if any irregularity had been observed in the instrument when exposed to all sorts of heat, and whether there was any trace of alteration with the rise and fall of the barometer.

Prof. FORBES, in replying, said the questions which had been put reminded him of the way in which different things cropped up in the course of the enquiry and of the way in which they had to be met, and the gradual development of the instrument. In the first place, he wished to tell Sir William Thomson that he sincerely felt the kind way in which he had referred to him (the speaker), and he was very glad that Sir William seemed to appreciate the instrument which he placed before the section. He (Prof. Forbes) felt honestly that it was really a good instrument. Sir William spoke about the self-induction and the effect of the unequal distribution that went on in the interior of the wire conductors during the time that an alternating current was passing through it. He confessed that when he got the meter pretty fairly into working order it was with some trepidation that he took it to the alternating current machine and began tests. His mind was full of the experiments on self-induction which Prof. Hughes had brought before them 18 months before, and which he (the speaker) had followed up in following up the work



of Prof. Hughes, and he felt that probably there would be a great difference. He found, however, that an alternating current did not introduce an apparent resistance in the same way, certainly not to the same extent, as a suddenly-made and broken current did, and that really in the experiments he had made with the alternating current machine he could not perceive the slightest difference in the effects whether it was with an alternating current or a continuous machine, or at whatever speed the alternating machine was running. Prof. Perry could not see any theoretical reason why the thing should work. That showed that Prof. Perry knew a great deal more about it than the speaker did when he began experimenting. Then it seemed to him perfectly evident that it must work—that it must be suitable for all currents—that the speed would be proportional to the current, owing to the fact that the resistance of the air friction was proportional to the square of the velocity, and owing to the fact that the motive power which was created—the heat—was proportional to the square of the current. They had known for many years that these two circumstances ought to make the velocity of the air current an exact measure of the quantity of electric current that passed through the conductor. To his astonishment, it was not so in the first meters that he made. He corrected that gradually, and ultimately evolved this instrument, different from the one which he thought would have been perfect, but which Prof. Perry thought ought not to be perfect—Prof. Perry was right and he was wrong. Mr. Trotter asked a question about the size of the cover. Undoubtedly the size of the cover made a very great difference. If he enlarged it from one size to another he was able to start with a lower current. The size made a great difference in the minimum current which would start the instrument. There was a difference of speed with the clockwork and without it. This was, however, almost imperceptible when it was really in working order, but there was a difference in the starting

with the clockwork on. It did not start with quite so small a current when the clockwork was on.

Sir FREDERICK BRAMWELL suggested that "wheel work" might be a better term than "clockwork."

Prof. FORBES thought it would be, inasmuch as some people might be led into the belief that there was a clockwork attached to it, which was not the case. With the wheel work attached it depended very much on the delicacy of the construction of the instrument. He had tried not to construct this instrument too delicately, and the practical instrument which he had been speaking of had no jewelled holes in the wheel work, and could be made at a pretty moderate cost. The instrument shown was started with one half the current that would be required if he took off the wheel work, but he had made meters in which it was much less. The principal friction was in the pivot, the jewelled cap resting on the pivot. The wheel work friction was very much less. Mr. Sellon asked whether there was any variation in the instrument due to atmospheric temperature, and, again, after it had been running some time. There was none. There was a period in the early stage of the instrument when it had a serious influence on it, but with the final development of the instrument there was absolutely no difference whether it was running for a long or a short period. For the first five minutes or so it took a little time to get up its full speed, so likewise it took a little time to slow down, but for all practical purposes, he thought they both balanced each other. It was a mere trifle, in any case. In reply to Mr. Upton, the speaker explained, by means of a diagram, when it commenced to rotate, and other details. The meters he had spoken of were supposed to be made for 30 lamps, and to indicate one lamp with fair exactness, but it would start with one half of that which was required for one lamp. Another gentleman asked whether the external temperature of the atmosphere or any barometrical influence affected it, and whether there was any barometrical correction necessary. In fact, nearly every person had asked him that question. It did not, and that was about the only part of the meter in which practice agreed with theory. It was a very curious thing, but it seemed at first sight as if a high temperature ought to make a difference, but when they remembered that the motive force was the difference of temperature in the neighbourhood of the conductor and the external air and not the absolute temperature of the wire, they would see that it did not matter whether the external air was 50 degrees or any other figure. As to barometric observations, he had made no tests to see whether there was any difference with variations in the barometer. He had tried the same instrument for long periods of time without finding any difference of the constant, and he was practically certain that the barometrical changes to which they were subject did not introduce changes in the meter. Since he had introduced the spiral conductors he had never had the slightest difficulty.

Sir FREDERICK BRAMWELL said they must recollect that there were two things needed before the meter became commercially useful. The first was that they should be allowed to use it without any restraint from anybody, and the other was that in using it they should have the means of charging to the consumers what was supplied to them. Prof. Forbes, he thought, had shown that he had invented a meter most simple in its principle and mode of action, and one that would truly indicate within such limits as were attained in gas meters (and they ought to desire nothing more) the amount of electricity which any person would have to pay for when they had succeeded in getting rid of those unfortunate restrictions which now prevented the supply of electricity from central stations.

FAST SPEED TELEGRAPHY.

By WILLIAM HENRY PREECE, F.R.S.

(Section G.—Mechanical Science.—September 5th.)

IN this Jubilee year of telegraphy many papers have been read, articles written, and speeches delivered on the progress made during the past 50 years, scientifically, practically, and commercially, but with very few exceptions has any justice been done to the advance made in England in the scientific direction.

Sir William Thomson said:—"You have told us how splendidly the land telegraphs are worked; you have pointed out how admirably under the influence of the Government system the application of science to telegraphy has been developed. Under Government management within these last 17 years the applications of science to telegraphy have not stood still, but, on the contrary, have been pushed forward with every possible energy and with the most marvellous success."

I want to describe the evolution of the system of high speed since it left the hands of Wheatstone and Mr. Stroh.

The following table illustrates the progress made:—

Year.	Words per minute.	Speed to Ireland.
1870	80	50·3
1875	100	70
1880	200	150
1885	350	250
Now	600	462

These results have been the consequences of—

1. Greater perfection of apparatus.
2. The elimination of electro-magnetic inertia.
3. The improvement of circuits.
4. Introduction of high speed repeaters.

Two reasons exist why these great advances have not received notice; they were not patented, and they emanated from Government service. A patent has certainly one great use, it fixes a date and it defines an invention, but it also attracts attention to novelties and improvements, and if the patent be lucrative it incites the immoral to try and do the same thing in another way, which tends to litigation, though it often results in still further improvements. There is a very ridiculous conception abroad and widely circulated, that commercial enterprise alone is competent to excite inventive skill. I have more than once contested this proposition, but with very little effect, for from the floor of the House of Commons, and from the columns of the press, there is the same cold indifference to the work done in Government departments, and the same cry as tersely put by *Nature*, "The feeling is 'What good can come out of Nazareth?'"

A complete set of automatic instruments consists of:—

1. The *perforator*, which punches a strip of paper with holes on the principle of the Jacquard loom, so as to regulate the number, order, and rate at which alternate currents of electricity are sent along a wire by

2. The *transmitter*, which is the automatic part of the apparatus, sending along the line those currents which at the distant end are recorded as words in the form of dots and dashes, replacing the slow and uncertain manipulation of the hand.

3. The *receiver*, which is an ink writer of extreme delicacy and great rapidity, recording the words in the Morse character.

1. The perforator has not been much modified since it left the hands of that accomplished mechanician, Mr. Stroh. Experience has brought out several mechanically weak points, which have been much simplified and strengthened. They have been made to a standard gauge, both as regards the number of perforations per foot,* the strength of springs, and the uniformity of parts, so that interchangeability is possible throughout the whole service. The fact that air pressure for working pneumatic tubes exists in many large post offices besides London has led to its application to punching, which is rather a severe mechanical labour, and it has rendered it possible by constructing double-banked perforators to punch eight slips at one time, an invaluable reduction of labour in the transmission of news which has grown to such gigantic proportions that frequently over 1,000,000 words have been sent in one evening from the central office in London.

2. The transmitter is an instrument designed to send as many reversals of current per second through the line as the retardation and the electro magnetic inertia of the circuit will allow. These reversals are rapid alternations of positive and negative currents, the former making dots and called the marking currents, the latter making spaces and called the spacing currents. When the transmitter runs free without any paper to guide it, these currents flow through the line with a regular frequency which is controlled by a beautiful excentric governor invented by Mr. Stroh. This frequency in the present transmitter can be regulated from 14 up to 240 reversals per second, which means 600 words per minute.

When unpunched paper is inserted a permanent current goes to line, the motion of the electrical contact that reverses the current is checked or hindered; when the paper is punched then a dot means a complete reversal, a dash means three complete reversals, but the middle one checked by the paper; a space means three complete reversals all checked by the paper. In the earlier form of transmitter the reversal was effected by a commutating arrangement which involved time, and which could not exceed a frequency of 48 or 120 words per minute. It was a very rapid double current key using one battery. In 1883 this plan was revised, a double or divided battery was used (fig. 1), earth being in the centre, the contacts being simple butt contacts.

The mechanism was thus very much simplified, and the possible speed of working increased to a frequency of 120 or 300 words per minute. Subsequently, in 1886, the divided battery was rendered unnecessary by a new form of contact of the same character (fig. 2), but requiring only one battery, and the possible frequency was increased to 240, or a working speed of 600 words per minute.

It is evident that with such rapid working the accuracy and perfection of the workmanship must be chronometric in its character. All automatic apparatus is made in the department's own workshops, where mechanicians of the highest skill are employed, where standard gauges are carefully worked up to, and where the most rigid system of inspection is exercised.

One source of trouble has been sparking at the points of contact, which dirties them by disintegrating the metal. Small condensers of $\frac{1}{10}$ microfarad capacity have been applied which considerably modified the evil; but it has been still further reduced by switching out the galvanometer while the transmitter is at work, for sparking is principally due to the presence of electro-magnetic inertia in the apparatus.

3. The receiver has been entirely remodelled both mechanically and electrically. The principal mechanical improvement has been replacing a spring as a motor by a weight in order to secure a more rapid and more uniform rate of running at high speeds, and as a receiver may at one moment have to record at 400 words per minute and the next at 25 when working by hand, it is clear that unless some governor be used the waste of paper would be excessive.

Improved flies have been applied to Stroh's excentric governor

* The standard is 120 centre perforations per foot, or, counting the first and last perforation, 121 centre perforations per foot.

so as to make it act with equal efficiency at the present high speeds. Thus, the length of the signals made and the length of paper used per twelve words is practically the same at high and low speeds.

It was thought at one time that the speed of working was limited by the retardation of the line circuit, but a careful inquiry into the phenomena of electro-magnetic inertia (*Journal of the Society of Telegraph-Engineers*, 1877, Vol. V., page 27) led me to the conclusion that the principal source of slowness was in the electro-magnet. It is not possible, owing to this electro-magnetic inertia, to establish *instantaneously* through a circuit containing an electro-magnet a current of the strength due to the electro-motive force producing and to the resistance regulating it. The current strength can be brought up only gradually to its proper value.

Every electro-magnet in a telegraph wire becomes an obstruction to the flow of currents, especially when these currents are rapidly intermittent or rapidly reversed. In telegraphs they lower the speed of working, in telephones they blurr the clearness of articulation. It is as though the passage for the flow of electricity were restricted, as the clear way of a water pipe would be

FIG: 1.

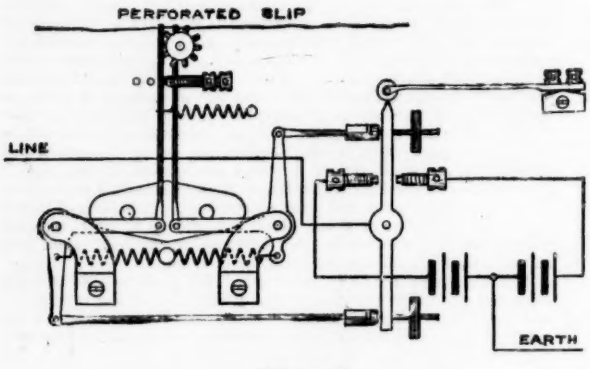
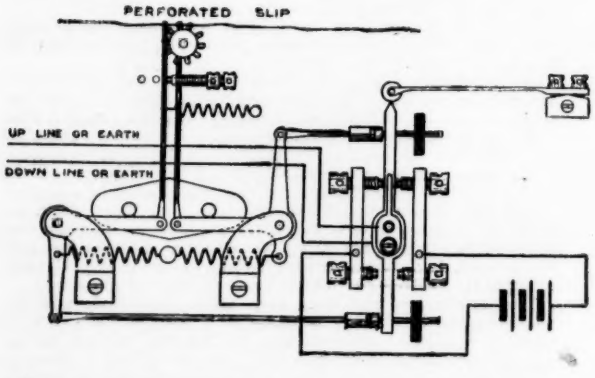


FIG: 2.



choked by the presence of a large stone in the pipe, or the efficiency of a gas pipe would be reduced by its being crushed in by a blow from the hammer. But the peculiarity of the electro-magnet is that the currents themselves cause their own hindrance, and the more frequent they are the greater the throttling or choking action. The action is not dissimilar to that of the throttle valve of a steam engine actuated by a centrifugal governor. Hence, Lord Rayleigh has lately proposed to apply the term "throttling" to this peculiar effect of electro-magnetic inertia. Every electro-magnet has thus a time constant which determines the rate beyond which it cannot work. This time constant can be obtained only by experiment, for it depends on the quality and quantity of iron used, on the form of the core, on the resistance and quality of insulated copper wire, on the number of turns, and on the way they are wound. The battle with self-induction has been a severe one. Years of labour were devoted to determine the proper conditions to reduce these disturbing elements to their minimum point of hindrance combined with efficiency, until fortunately a means was discovered to entirely eliminate their influence.

Every electro-magnet wound to a resistance, R, has its own co-efficient of self-induction, L, which determines the rate at which a current rises or falls, and the time constant is expressed by the ratio $\frac{L}{R}$. It is the time the current takes to rise from zero to full value.

If the two plates of a condenser of capacity, K, be shunted by a wire of resistance, R_1, then when a current flows the condenser will be charged and the current will consequently gradually rise to its full value, and if the current stops the condenser will discharge and the current will in the same way gradually fall to zero. The time constant of such a condenser is $K R_1$. This is exactly the same kind of action that takes place in an electro-magnet, and by properly regulating the size of the condenser and the amount of resistance the one can be made to exactly reproduce the former.

Now, if we connect up an electro-magnet and a condenser in the way shown in the following diagram (Fig. 4), then, whenever the main current ceases, there is an electromotive force in the magnet due to L, tending to prolong the current in the direction (*l*), while there is an E.M.F. in the condenser, K, due to the charge tending to do the same thing, but in the opposite direction (*k*). Hence, these two effects oppose and neutralise one another when the resistances, R and R_1, the coefficient, L, and the capacity, K, are properly adjusted.

Maxwell has shown that when an electro-magnet and a condenser are balanced in a Wheatstone bridge, $L = R R_1 K$, but in the shunted arrangement (as shown in appendix),

$$L = R_1^2 K.$$

FIG: 3.

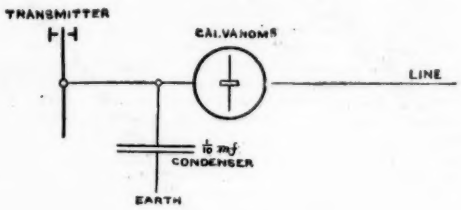


FIG: 4

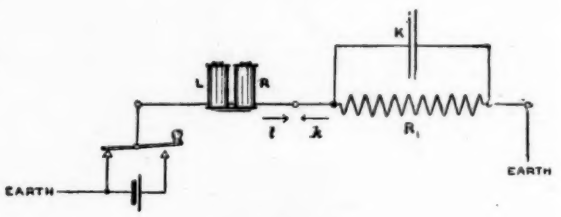
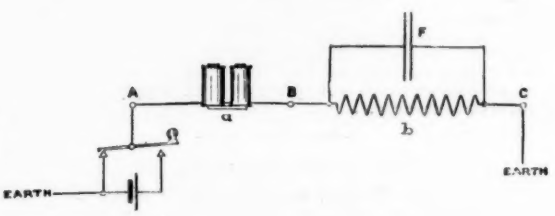


FIG: 5.



The introduction of the shunted condenser has had the most marvellous effect on the speed of working. It has entirely eliminated any hindrance caused by the electro-magnet, and now the only cause of slow working is the mechanical efficiency of the apparatus and the condition of the circuit. I have pointed out in another paper how copper wire has removed electro-magnetic inertia from the wire, and there remains only the retardation (K R) of the circuit to check speed of working.

Four hundred and fifty words a minute is now obtained with ease on circuits of 200 miles in length, and we have on some circuits reached 600 words per minute; but 450 is more than we can practically cope with, and, therefore, at present the apparatus exceeds in efficiency the capacity of the staff; but this speed rapidly falls off as the retardation of the circuit increases, and while we can work at the highest speed between London and Leeds, we can only get one fourth of this speed to Glasgow. If, however, we place at Leeds a repeater, which will respond to and relay on these frequent currents, we ought to get the maximum speed to Glasgow, and this is done by the high-speed repeater. The high-speed repeater contains on one board all the electrical functions of two transmitters and two receivers. All causes of hindrance are removed from it, and it works at the highest possible speed. Electrically it is an exceedingly complicated piece of machinery. It owes it efficiency to the perfection of the Post Office standard relay—a relay which has practically no time constant, which responds to exceedingly delicate currents, and which makes perfect electrical contacts—and to the use of condensers.

These repeaters are very extensively used. There are special

relay offices at Haverfordwest, Nevin, and Anglesey to provide full speed to Ireland. The speed to Ireland in 1870 was 50 words per minute. It is now 462 words—a ninefold advance. Leeds, Manchester, Bristol, and Preston have also special relay rooms. There are 101 repeaters in use. Some circuits, such as those to Aberdeen, have two repeaters in circuit, one at Leeds and the other at Edinburgh. In fact, these high-speed repeaters enable the highest possible speed of working to be obtained to every part of the United Kingdom. They are arranged so as to be used at will either for automatic or for ordinary key apparatus, and either for simple or for duplex working under each class of working.

The introduction of high-speed repeaters and the use of shunted condensers have marked epochs in the evolution of telegraphy as eventful as the introduction of duplex working or of the telephone. The various stages of improvement which have been narrated in this paper would each form the subject matter of a patent were it the habit in the Government service to patent. Had the telegraph service been conducted under the severe competition of private enterprise, each form of transmitter and of receiver, the relay, the high-speed repeater, the shunted condenser, and every other improvement would have been patented, and would have been found worthy of substantial reward.

I may add that in bringing about these improvements I have been most ably assisted in the mechanical department by Mr. J. W. Willmot, now the head of our workshops, and in the electrical department by Mr. J. B. Chapman and Mr. A. Eden, both accomplished practical electricians.

Appendix.

If E be the E.M.F. at any moment taken between A and C (fig. 5), e_1 that between A and B, and e_2 that between B and C, also if a be the resistance between A and B, b that between B and C, then

$$\begin{aligned} E &: e_1 :: a + b : a \\ E &: e_2 :: a + b : b \end{aligned}$$

$$e_1 = E\,\frac{a}{a+b},$$

$$e_2 = E\,\frac{b}{a+b}.$$

The quantity in condenser is

$$Q = e_2 F = E F\,\frac{b}{a+b},$$

and that discharged from condenser through a is

$$q_1 = Q \cdot \frac{b}{a+b} = E F\,\frac{b^2}{(a+b)^2}.$$

Again, the quantity discharged from the magnet is

$$q_2 = L\,\frac{E}{a+b} \cdot \frac{1}{a+b} = E L\,\frac{1}{(a+b)^2}.$$

But $q_1 = q_2$

$$E F\,\frac{b^2}{(a+b)^2} = E L \cdot \frac{1}{(a+b)^2},$$

or

$$F b^2 = L.$$

Discussion.

The Chairman (Sir Frederick Bramwell), in opening the discussion, said they would agree with him that it should not be allowed to branch off into a question of the expediency of the patent laws, notwithstanding the temptation thrown out by Mr. Preece to do so. He did not say that it was not a subject very much within the competence of Section G., though it was rather more suitable for Section F. But there was a more important scientific side to the subject which many gentlemen present were quite able to discuss.

Sir William Thomson, who said he had not been present to hear the whole of the paper, congratulated Mr. Preece upon the great success which had been attained under his management in the practical work of telegraphy in the United Kingdom. The figures he had put before them were really of a most remarkable kind. One question with reference to the 600 words a minute which he would like to ask was whether they were all sent in one direction, or in both directions at the same time. He gathered that it was the whole of the work done on the wire in two directions at once. He should be very glad to hear that a speed of 600 words all told in both directions was attainable.

Mr. Preece: They are all in one direction.

Sir William Thomson: And is the instrument capable of being worked 300 words in one direction and 300 in the other, or only in one direction?

Mr. Preece: Only in one direction. I have made no reference to duplex working. We have found when working duplex that we can only get half the speed in each direction, so that if we were working at 600 we could only get 300 words in each direction in the minute.

Sir William Thomson said he was thinking of the very beautiful system of Delany which was now in use. But he understood that this was the Wheatstone instrument and worked in one direction only. They would all, he was sure, be glad to hear one word from Mr. Preece as to whether the Delany system had come into considerable use since he explained it to the section last year.

Mr. Preece said it would be a great gratification to him if he knew from Sir William Thomson that he had explained the action of the shunted condenser.

Lord Rayleigh observed that he was very much interested in Mr. Preece's description of recent progress in the matter of telegraphy. He had really no knowledge of it himself; but there was just one reference that he would like to mention, which he thought many practical telegraphists did not know about although some scientific electricians did, and that was the paper appearing some years ago in the Transactions of the Edinburgh Society, by Chrystal, who discussed in considerable detail a large variety of arrangements such as that to which Mr. Preece had called their attention, and the relations of electro-magnets and resistance condensers, investigating very fully the electrical property involved. No doubt the property used in this particular arrangement was set forth in that paper. One question which it occurred to him to ask Mr. Preece was if he could give them some comparison between the fast speed rate of telegraphy and the highest rate to be attained by telephony. That would probably convey a definite idea to the minds of many present.

Gen. Webber said there was one point which he thought would be very interesting to the meeting to hear from Mr. Preece, and that was the number of individuals that it was necessary to employ at each end of the circuit worked in the way so as to obtain from it its full capacity of 600 words per minute.

Prof. Perry had nothing to say upon the paper except to make a reference to the scientific description—the exact mathematical description—of the negative effect which a condenser shunting a resistance had. The condenser acted as a negative self-induction. Mr. Preece's popular description was of considerable value, but the exact mathematical description, very simply put indeed, would be found in a paper by Mr. Sumpner recently published in the *Journal of the Society of Telegraph Engineers and Electricians*.

Mr. Kapp asked whether this was the only arrangement of a shunted condenser in use, or whether in some cases Mr. Preece put the plates of the condenser to the terminals of the electro-magnets, which would, he believed, act in the same way, though perhaps it would not do exactly what this arrangement did for telegraphy.

Mr. Faulkner wished to know whether Mr. Preece had found any difference in speed when using a common electro-magnet and when using a Faulkner electro-magnet.

Mr. Trotter put a question which he thought any telegraphist would probably know, how many separate impulses were meant by 600 words a minute? How many letters went to an average word, and about how many impulses to a letter?

Mr. Snell asked whether the capacity of the condenser required adjustment when working at different rates of speed, or whether the capacity would remain constant and give sufficiently good results at very different rates of working.

The Chairman said Mr. Preece would in his reply perhaps touch upon the question put by Sir William Thomson, although it really formed no part of the present paper.

Mr. Preece: Sir William Thomson asked a question about duplex working and I think I answered it at the time, but I will again refer to this point because it is scientifically an extremely interesting one indeed. We have found—taking the line from London to Dublin, which I have still in my mind—that with a shunted condenser arrangement and all the latest improvements the highest speed that it has been possible to get out of the circuit has been 462 words per minute. That shows that the speed is not limited by the apparatus used but by the circuit. We found that working duplex on the same circuit we got 231 words a minute each way showing that the speed of 462 words a minute was obtained by utilising every impulse that could be passed through the circuit, and that when we revert from simple to duplex working we can only utilise the number of reversals or simple currents. Before we reached this limit it was a common thing to find that the sum of the two workings duplex was smaller than the working single, and that we had not reached the maximum efficiency of our circuit. But now these experiments between London and Dublin have quite satisfied me that at the present moment we are getting out of our circuit all that it is possible to get out of it. But it is a case of "never say die!" All the work of the last year has shown that their is room for improvement. With reference to what Lord Rayleigh has said I may say that the sole reason why we have so persistently pegged away at this high speed working has been the fact that the telephone has been brought out, and that it is possible to get a number of impulses through a circuit infinitely greater than was thought possible before the telephone was introduced. Our eyes have been opened enormously by this beautiful and simple telephone apparatus. I read last year before the Royal Society a paper upon this subject showing that the law regulating the distance to which we can speak by telephone is precisely similar to that of Sir William Thomson regulating the number of reversals that pass through a current. I am afraid that many of my friends are not quite satisfied that I have made my case very clear or strong, but if I have not done so it has been from my inability to do so. But I am perfectly certain of this, the more they study the subject, the more they work with a high-speed current and telephony, the more surely they will find that there is practically no difference whatever between the currents used for telephonic purposes and those used for high-speed telegraphy. Sir William Thomson

asked about Delany. The Delany apparatus is another advance in telegraphy in another direction and for another purpose. We ordinarily work a telegraph simple, or simplex, that is, one message in one direction at one time; duplex working means two messages going in opposite directions at the same time; quadruplex means four messages in opposite directions at the same time, so that four messages are passing through a wire simultaneously. But the Delany multiplex has enabled us to send six totally different messages through the same wire at the same time. These messages need not be in reverse directions; all may be in one direction, or one in one, and five in another, or they may be mixed up in any combination of six. Sir William Thomson will be glad to hear that we are developing this system very fast indeed. We are, I think, improving it. We find great difficulty in surmounting the effects of the capacity of our wires, but we are now working from London to Birmingham, from Birmingham to Manchester, from London to Manchester, from London to Leeds, and from Leeds to Carlisle, and this week we are working from London to Glasgow with repeaters at Leeds. In the last paragraph of my paper I have referred to the assistance I have received in carrying out all these improvements in fast-speed telegraphy from Mr. Willmot, who is at the head of the workshops, Mr. Chapman, who takes immediate charge of the high-speed telegraphs and high-speed repeaters, and especially from Mr. Eden, my assistant here, to whom alone is due the way in which the application of condensers has been so carefully carried out. I have only referred here to one use of condensers. They are being used for all kinds of purposes, and the manufacture of condensers is becoming a very important part of my business. Mr. Eden has just returned from Leeds, and he tells me that we have now established between London and Glasgow a Delany multiplex apparatus with repeaters at Leeds. I hope next year to be able to read a paper upon this subject. Prof. Perry has referred to an extremely able paper by Mr. Sumpner. As a matter of fact, the whole telegraphic world is indebted to Profs. Ayrton and Perry for the way in which they brought the subject of self-induction before the Society of Telegraph Engineers and Electricians, and their pupil, who developed the subject, showed what admirable means of instruction are to be obtained at the City and Guilds of London Institute if only we send our sons there. Profs. Ayrton and Perry have devised an instrument for measuring this electro-magnetic inertia. I am going to bring the subject before Section A to-morrow, and, therefore, pass on for the present. Mr. Kapp asked if we have used the condenser as a shunt to the electro-magnet. Of course we have tried that, but, as a matter of fact, if the condenser is used in any other way than that shown it acts as a positive and adds to the retardation of the capacity of the circuit and has a deterring influence. Mr. Faulkner asks if we have found good results with his magnet. If Mr. Faulkner reads the paper, and learns a little more about magnetic inertia, he will find that his magnet has a deterring influence rather than a beneficial one on the speed of working. Mr. Trotter asked how many reversals of current there were. Well, it means 240. The frequency is 20 per 50 words, so that if you know the rate at which we are working you get at the frequency at once. When we work at 20 reversals per second it means 50 words per minute.

Sir WILLIAM THOMSON: Ten periods, I understand.

Mr. PREECE: No; 20 periods—20 positive and 20 negative. It is the whole period of the positive and the negative. Mr. Snell asks if we find any variation in the capacity with different speeds. We do not. We find it when working with iron wire, but when working with copper wire at higher speed we find no difference whatever with variation in speed. That is a point I shall refer to to-morrow.

The CHAIRMAN called upon the meeting to accord a vote of thanks to Mr. Preece, and his request was heartily complied with.

ON THE INFLUENCE OF A PLANE OF TRANSVERSE SECTION ON THE MAGNETIC PERMEABILITY OF AN IRON BAR.

By Prof. J. A. EWING, F.R.S. (University College, Dundee), and Mr. WILLIAM LOW.

(Section A.—Mathematical and Physical Science.)

Tuesday, September 6th, 1887.

IT has been remarked by Prof. J. J. Thomson and Mr. H. F. Newall, that when an iron bar is cut across, and the cut ends are brought into contact, the magnetic permeability is notably reduced.*

Our attention was drawn to the matter in experimenting by the "isthmus" method described in former papers, when we attempted to use, instead of a solid bobbin, a short cylinder for the narrow central neck, separated by transverse planes of section from the conical ends. We found that even when such a cylinder was placed in close contact with the ends of the cones the induction in it was much smaller than in the neck of a solid bobbin of corresponding size; and we were forced to ascribe this defect of permeability to the fact that the induction was being measured at a place only a little way from two planes of transverse section. To examine the influence of transverse section more fully, and to see how far that influence is modified when the pieces are pressed against one another, we made a separate series of experiments, in which the permeability of cut and uncut wrought-iron bars was determined by a method similar to that used by Dr. J. Hopkinson.†

The bar to be tested was let into a massive rectangular yoke of wrought-iron, forming a double path for the return of the lines of induction from end to end.

The effect of this is to get rid in great measure, though not completely, of the self-demagnetising influence of the bar's ends, so that the metal may be tested in a condition approximating to endlessness. The ends of the bar were sunk into holes bored for them in the yoke; one abutted against a fixed stop; on the other a plunger rested which was carried through the yoke, and could be loaded on top by means of a lever so as to produce a stress of compression in the bar.

The clear length of the bar between the inside faces of the yoke was 12·7 cms. Its area of section was 0·494 sq. cms., and that of the two sides of the yoke, taken together, was 51 sq. cms. The bar was wound along its whole clear length with a magnetising solenoid, through which currents of various strengths were sent from a battery of accumulators.

The magnetic induction was determined by reversing the current in this solenoid, and observing the transient current induced in an induction coil less than 1 cm. long wound at the middle of the bar.

The results can be stated here only very shortly. First a solid wrought-iron bar was tested without compression, and then under a compressive stress of 226 kilos per sq. cm.

Then the bar was cut into two parts at the centre and tested again, with and without the same load. Again it was cut into four parts, and finally into eight parts, and was tested with and without load in each case.

Each cutting caused a notable loss of permeability. The following are the values of the maximum ratio of magnetic induction ($\mathfrak{B}$) at the middle of the bar to the magnetising force due to the solenoid when the bar was tested without load.

Solid bar	1220
Bar cut in two	980
Bar cut in four	640
Bar cut in eight	400

The effect of loading was very remarkable. The curve of $\mathfrak{B}$ and $\mathfrak{H}$ in the solid bar is depressed by compressive stress with moderate values of $\mathfrak{H}$—that is to say, the bar is less susceptible to magnetisation under compression. The same effect is seen when the bar is cut in two. When the bar is cut in four, loading produces almost no change in the susceptibility, and when the bar is cut in eight, loading produces a marked *increase* of susceptibility. Subjecting a cut bar to compression has two antagonistic effects on its magnetic permeability; it reduces the permeability by its effects on the solid portions; it increases it by its effect at the places of section; and, when these are numerous enough, the second or positive effect swamps the first or negative effect.

Next, another bar was tested (with and without load) first when solid; then when cut at the middle into two parts, the cut ends being in the ordinary state as they left the lathe; and lastly, with the cut ends carefully faced up to the condition of true planes by scraping and comparing them with a standard Whitworth plane. So long as the bar was not loaded the magnetic susceptibility in the second or rough-cut state was much the same as in the third or faced-true state; in both it was notably less than before the bar was cut. But when the load was applied a remarkable difference was exhibited. The rough-cut bar, as in the former specimen with one cut, had its susceptibily reduced by compression; the faced bar, on the other hand, suffered no material change. The curves of magnetisation and field for (1) the rough cut bar without load, and (2) the faced bar without load are nearly coincident; and so are those for (3) the faced bar with load, and (4) the solid bar with load. This result was confirmed by independent experiments with another sample.

When the ends of the cut bar were faced true the two effects of compression (by the particular load used in these tests) practically neutralised each other; when the bar was rough-cut the negative effect was the stronger. The chief result of facing the ends is to augment the positive influence of the load. When loaded the cut bar with faced ends is in fact almost undistinguishable as to its magnetic permeability from the same bar in the uncut state.

The influence of a plane of section may be demonstrated by comparing the magnetic induction through and close to the plane of section of a cut bar, with the induction in parts of the bar lying at some distance, by slipping an induction coil along the bar.

In our experiments, however, this showed only a small part of the whole effect. A comparison of induction measured by means of coils placed at other parts of the length as well as at the middle of the bar, both before and after the bar was cut, showed that a single plane of section at the middle reduced the induction along the whole length to a remarkable extent, though its influence was of course most marked in the portions nearest to the plane of section.

The results make it highly probable that the effect of a plane of section in reducing the permeability of an iron bar, is wholly due to air-space between the cut faces. Using the method which Hopkinson has employed in predetermining the induction in dynamo cores, in which the line-integral of the magnetising force

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* Proc. Camb. Phil. Soc., Feb., 1887.

† Magnetisation of Iron, *Phil. Trans.*, 1885, Part II.

is equated with the line-integral of the induction divided by th permeability, we have calculated the thickness of air-space required to account for the defect of induction which we have observed. We find that when a cut bar is exposed to a magnetising force of 10 C.G.S. units, the air film must have a thickness of only 0·028 millimetres to explain the loss of permeability. And when the bar is cut into four or into eight parts, the whole defect of induction is completely accounted for, if we suppose each cut to introduce an air film of about this thickness. Under stronger magnetising forces the thickness of the supposed air film is reduced, as we should expect, so that when the magnetising force is about 50 C.G.S. units, the thickness of the film is only 0·014 mm., or half the above.

Discussion.

Mr. Glazebrook said he happened to have a proof of a paper on a similar subject by Prof. J. J. Thomson, and he might as well put the figures of the latter on the board, so that they might be compared with those of Prof. Ewing. In those experiments a bar of iron 10 cm. long was employed, which was cut in two; the ends were turned in a lathe roughly, then worked with a true plane as near as could be, and then Prof. Thomson made observations of the same kind as those of Prof. Ewing, separating the ends by one-hundredth of a diameter, two-hundredths, and so on. He would take one of the numbers on the board, referring with a magnetising force of 200, which he (Mr. Glazebrook) thought was stronger by four times than Prof. Ewing's. Taking that case only with a continuous core, the induction observed was 6048. With the ends cut and turned in a lathe, then worked up to a true plane and pressed together with a wooden clamp, the induction came to be 5472. With the ends turned as plain as they could be got the induction was 6,000, and with the ends separated by one one-hundredth of a diameter, it was 5,328. Prof. Thomson said in the conclusion of his paper that the results were just as might be got if Green's expression were taken for the distribution of magnetism on a bar or cylinder placed in a uniform magnetic field.

Prof. Perry: Was there iron connection between the ends?

Mr. Glazebrook: There was no iron connection between the ends.

Lord Rayleigh: Was there any estimate of the air space required to explain the results?

Mr. Glazebrook: There was no estimate.

Sir William Thomson said what occurred to him as of some interest in connection with the physical properties concerned was, that when the ends pressed together were not perfectly true the stress would be enormously different in different parts, and they knew that the effects of stress on magnetisation were far from being in simple proportion to the pressure stress; very intense in one part and not so intense in another, would produce a very different effect from the uniform stress which existed in different parts of the iron. That no doubt would produce some complication in estimating the effects of stress which Prof. Ewing described. One question which he would like to ask was, was there any effect of instability, or anything to prevent the effect of instability?

Prof. Ewing: As a matter of fact the bar was enclosed in a paper tube, which was enclosed in a solenoid of thick wire. It was perfectly stable.

Sir William Thomson said it would be exceedingly interesting if Prof. Ewing would, with his apparatus, repeat the experiment, introducing a thin film of gold leaf. He (Sir William Thomson) had almost no doubt the result would be negative, but still it would be satisfactory just to know whether magnetic contact between iron and iron was or was not necessary. There was one other little point of interest. Was it possible to have in air or in gold leaf such an exceedingly intense field as 50,000 C.G.S. The field of the so-called induction, that was to say, the magnetic force on an ideal of the unit of the pole in a slot perpendicular to the lines of force, had been raised to a value not far from 50,000 in some of Prof. Ewing's experiments, by far the greatest figure ever attained. He had on a previous occasion inadvertently said that luminiferous ether had nothing to do but transmit light; but it must also be capable of exhaustion of energy at the rate of 50,000 times 50,000, 2,500 million C.G.S., or 2,500 million ergs. per centimetre, so that if there was to be any kinetic theory of the ether whatever which was to be anything more than a mathematical abstraction it must be shown to be capable of having its energy reduced or exhausted at the rate of 2,500 million C.G.S. per cubic centimetre. There was something very interesting indeed in estimating the extreme limits of magnetic force actually obtained. They had a limit of magnetisation in iron. Had they or had they not an absolute limit to the amount of magnetic force transmissable through air or gold leaf or a vacuum? He thought to solve that question would be splendid work.

Prof. Silvanus Thompson asked if Prof. Ewing had tried whether after the diminution of the pressure the film of air left between the two pieces of iron remained in a good magnetic state. The question was a little important to those who built dynamos, for it made a very great difference in the making of the magnetic circuit. It might be well to put dynamos together under pressure, unless the film between the pieces could be put back again.

Prof. Wiedemann said it would be very interesting to remember an experiment made in the beginning of the century. The experimenter, when magnetising an iron or steel bar by drawing a magnet over it, put a very thin film of oil over the bar. He could not then get magnetisation. When he took off the oil the bar was immediately magnetised.

Mr. Trotter said this was a very important matter for dynamo makers. He had found in calculating the magnetic resistance of the field magnets of dynamos that the resistance of the joints had to be allowed for. He had endeavoured to reduce this resistance to a minimum, actually working the surfaces by scraping and the use of surface plates. A considerable amount of high-class workmanship had been expended in this direction with the hope that the resistance of the joints would be reduced. When the question arose in the design of a new machine as to the probable effect of increasing the number of joints, an experiment was tried to determine the resistance. The upper bar of an inverted single horseshoe was separated from the side bars, first by the thickness of a sheet of paper, then by greater thicknesses up to an inch. It was found that the increase of resistance was simply proportional to the distance, being merely the resistance of the air. No rapid decrease was found, as was expected, when the distance was small, and hence it was assumed that special pairs in accurately surfacing the joints were not required. From knowledge of the resistance of the different qualities of iron employed he found the resistance of the joints between wrought iron and wrought iron to be equivalent to about 8 inches run of bar of the area of the joint. The same value was assumed for wrought iron and cast iron, and he had found that letting the end of a bar of wrought iron into a well-fitting hole of a depth equal to its diameter produced no perceptible diminution of the resistance of the joint. Considering the large surfaces with which dynamo makers had to deal compared with the area of the bar used by Prof. Ewing, and the great force that was found necessary to produce perfect magnetic contact, he (the speaker) was of opinion that it was useless for the dynamo maker to hope to introduce any improvement in this direction, either by accurate workmanship or by tightly screwing the bars together. Dynamo makers were none the less indebted to Prof. Ewing because this knowledge was of a negative character, for it would leave them with one direction less in which to work in improving their machines.

Lord Rayleigh asked Prof. Ewing if he had rightly understood him as to the thickness of the film necessary to explain the magnetic effect of a joint. It seemed to him from the figures given that it would come to about one-thousandth of an inch. One could hardly suppose that two reasonably good surfaces in contact would be separated by such resistance as that. It was about 40 wave lengths of light.

Mr. R. P. Sellon said with regard to the necessity of true joints, speaking as a practical dynamo builder, he thought the explanation of the fact that in dynamos they were not able to find any material difference, if the surfaces were very smooth or tightly clamped together, was that the whole resistance between the magnetic limbs and the frames or yokes of the dynamo was very small indeed compared with the resistance between the pole-piece and the armature. In the case of the Brush machines he had actually tried the experiment of loosening or slackening away the bolt which held the magnetising limb on the frame, and there the limb was simply dependent upon a single bolt; but he had found that it was possible to slip away the bolt very materially indeed, so that one might imagine that there was a film of air between the surfaces.

Mr. W. B. Esson said it was evident, from Professor Ewing's curves, that the difference made in the permeability by increasing the pressure between the joints depended entirely on the degree to which the magnet was saturated; whereas, the difference at the beginning of the curves with low degrees of saturation was quite conspicuous, when the magnet was pretty well saturated the difference was inconsiderable. In dynamo machines they worked with the magnets fairly well saturated, and the working of the joints to a true plane consequently became a matter of small importance. The advantage to be derived from such nicety of workmanship would not really compensate for the extra work involved.

Mr. Love said the method he had adopted had been by using a circle of iron, so as to get as good a contact as he could. After doing that he had experimented to find a permeability of the iron; first, when the ends were firmly pressed in contact, and, after that, when they were separated by known intervals. The resistance of air space thus made was proportional to its length. Then, with regard to Prof. Ewing's curves, he had made an experiment in which he got an air space of about a quarter of a millimetre wide. That seemed to answer pretty much to Prof. Ewing's calculation of the value of the air space in the place where he cut his bar into eight pieces. As far as he could see, looking at the curves from the position in which he was standing, his curve was almost exactly identical with Prof. Ewing's in every respect with regard to shape, and, as far as he could remember, as regards height, too. But between zero and the lowest part of the curve, for inductions of 0 to 2,000, the curve entirely changed in shape, becoming concave upwards.

Prof. Fitzgerald said, with reference to the remark of Lord Rayleigh, that it was true that two pieces of glass could be put together with facility, so as to leave an air-space of no more than a few wave lengths. He thought, at the same time, that anyone experimenting with flat pieces of glass, without the application of pressure, would not reduce the air space to so small an amount by any means. It was necessary to apply very considerable pressure before the layers of air would be squeezed out from between them. It was also necessary to take great care in heating the surfaces of glass if they did not want particles of dust to remain between them. He would like to ask Sir Wm. Thomson why he did not, in his paper on the previous Thursday, lead them to expect an energy per cubic centi-

metre of 1,000 million million million units; possibly the remarks he had made that day were intended to lead them up, so that they might not be frightened by the enormous number he was going to mention afterwards.

Prof. EWING, in replying, said Sir Wm. Thomson had asked whether there was any evidence of a limit to the possible number of lines of force per square centimetre in air, and what was the highest numbor that had been reached. The greatest number of lines of force in air Mr. Low and he had obtained was between 25,000 and 26,000 per square centimetre. There was nothing whatever to indicate that there was any serious difficulty in getting as many more as might be desired. If there was any physical object to be served by forcing more lines into air, to see how far they could go, no doubt they could do it with a slight modification of their present apparatus. Prof. Silvanus Thompson asked whether the film of air between the carefully-faced surfaces reappeared after the stress was removed. In their experiments it did so, but that might have been due to the fact that they always gave the bar a strong magnetic shaking up before measuring the induction. Each measurement of induction was made by reversing the magnetic state of the bar; and, in order to get rid of previous magnetisations, they reversed the magnetism many times before each reading. Of course this must have given the bar a powerful magnetic shaking up, and he had no doubt that would be of itself sufficient to account for the reappearance of the film of air. Mr. Trotter had referred to the application of this matter to the joints in dynamos, between yokes and cores, and so forth. Curiously enough there appeared to have been for some time a very general impression in the minds of dynamo makers that there was a surface resistance to magnetisation. He had come across this impression even before Prof. J. J. Thomson's discovery was published, and he was at first inclined to regard the impression as an incorrect one, but it was not so. It was perfectly correct that there was a surface resistance, but this resistance was probably due to nothing else than the distance by which the iron surfaces were separated. But, as Mr. Sellon had pointed out, this was not a matter of much moment in a dynamo, simply because in another part of the magnetic circuit there was a great deal of air space, and putting a little more at the joints did not make any material difference. Lord Rayleigh referred to the difficulty that such an interval as they were obliged to assume seemed greater than was likely to occur in ordinary joints. He was sorry they had yet made no attempts to measure the intervals directly; they hoped to do this. But he thought they might anticipate such an interval as the 35th or 70th of a millimetre when they considered the process of finishing a bar in a lathe. The end was not properly a plane at all, it was always more or less a cone, so that contact took place between two parts of a cut bar either on a circular ring near the outside, or on a small circle at the centre. The area of that contact was no doubt materially increased when the pieces were pressed together; but still, as these experiments seemed to show, the mean distance was not very much diminished by compression. As regards the question whether such a distance between the surfaces could exist when they were faced truly plane, he thought they had a good deal of independent evidence that such a distance might be looked for. In the well-known experiment of floating one Whitworth plane upon another, unless they forced the planes together, and gave them time to approach, they would find a marvellously small amount of friction; showing, in fact, that there was a very sensible air film between the two, which was only gradually expelled. It might be imagined that the film would have vanished in these experiments, since the pieces were in contact for a considerable time; but he thought the film might have been caused to reapppear by the magnetic shaking which the bar got just before the test was made. Another speaker had referred to the form which those curves would take if the experiment was made between zero induction and low values of induction. It was quite true that there they would expect, by the air film theory, that the difference between a cut bar and a solid bar would become very much less at low values of the magnetisation, simply because the permeability of the iron was then very much less. He ought to have said that Prof. Fitzgerald had anticipated his answer to Lord Rayleigh's question.

NOTES.

Electric Lighting at Brighton.—At the Brighton Town Council last week a letter was read from Messrs. Laing, Wharton, and Down, electrical engineers, enquiring whether the Corporation would rent arc lamps from them if they established a station in Brighton. It was resolved to thank the firm for their letter and to inform them that at present there was no intention on the part of the Council to light the town by electricity. At the same meeting, several emphatic protests were made against the insufficiency of the lighting arrangements in several parts of Brighton.

The Electric Light at Theatres.—One of the lessons to be derived from the recent catastrophe at Exeter Theatre undoubtedly is that all places of amusement should, if only in the interests of safety, be lighted by electricity. In several large towns the question of abolishing gas is under serious consideration, but whilst his *confrères* are in a state of inglorious uncertainty the lessee of Torquay Theatre has arrived at the commendable determination to adopt the improvement without delay. Mr. Massingham has been invited to carry out the work, but has been compelled to decline owing to pressure of business.

At Lyons, Marseilles, and Toulouse the municipalities are in treaty with the local gas companies to supply the theatres with electric lights.

At the Municipal Theatre, in Marseilles, there will be 300 incandescence lamps to light up the stage and its accessories. The auditorium, passages, and stairs will still be lighted with gas. The forfeit for every failure of the light is to be 75 francs per representation.

At Toulouse the gas company undertakes to fit up 1,000 incandescence lamps at the Capitol Theatre for 12,000 francs for a minimum of 200 performances. For every performance beyond this minimum the charge is to be 150 francs. This amounts to the modest figure of two centimes hourly per lamp.

The Theatre Olung is to be lighted electrically by the Edison Company.

Light from Wind.—Under this heading the Paris correspondent of the *Times* telegraphed last week as follows: "Experiments are being made at Cap de la Hève, near the mouth of the Seine, on the production of electricity for lighthouse purposes by means of the force obtained by windmills. The suggestion to do so was made by the Duc de Feltre, and it is a system proposed by him that is to be tested. The wind works a dynamo-electric machine employed in charging accumulators of suitable capacity. The electricity so produced and stored is to be used at will to make a focus of light. The system, if successful, will have the advantage of costing only the putting up of the machinery. The whole question to be ascertained is whether a sufficient quantity of electricity can be stored to provide for the requirements of any particular station when there is no wind to move the sails of the mill. M. de l'Angle-Beaumanoir, a civil engineer at Paris, has been authorised by the Minister of Public Works to make, at the expense of that department, the trial of this system of electric lighting at the La Hève lighthouse. The experiments will in no way endanger or inconvenience navigation, as the present machines are at hand to be used should the new system fail to work." This old idea has been tried many times, and once again we opine it is doomed to failure.

Mid-Lothian Road Trust and Telephones. — Mr. Macfie, of Dreghorn, has issued a printed statement to the members of the Mid-Lothian Road Trust in regard to the grant by the County Road Board to the National Telephone Company to place certain lines of communication through the eastern part of the county, with two call boxes and a short length from the western confines of the county to the Oakbank Oil Works with a subordinate call-box at Mid-Calder. Mr. Macfie says the privilege conceded to the Telephone Company may some day be worth hundreds of thousands of pounds. The whole area of the Water of Leith above the city and the Upper Esk and a number of important and populous places in the county have been left unprovided, making it improbable that any other company will enter the field, and constituting a valuable unlimited monopoly. Mr. Macfie, at the next meeting of the Trust, intends that portion of the report referring to telephony be referred back to the Board in order to its being reconsidered.

Gülcher Electric Light and Power Company.—Mr. Daniel de Castro, erstwhile chairman of the Gülcher Company, now acts as liquidator in the winding-up proceedings which, as we stated last week, are being conducted under the supervision of the Court.

Call Offices at Bournemouth.—In connection with their exchange at Bournemouth, the Western Counties and South Wales Telephone Company have recently established two public call rooms, where upon payment of 3d. anyone may engage in conversation with a subscriber. One room is at Westbourne and the other is at Boscombe. There is every probability that both will be liberally patronised.

Telephonic Communication between Ships.—Others beside Mr. Edison appear to be giving attention to the subject of telephoning between ships at sea. Prof. Blake, of the Rose Polytechnic Institute, described at the meeting of the American Association for the Advancement of Science, a method whereby a sound-producing apparatus is to be attached to each vessel and to be worked under the surface of the water. In time of fog or night a code of signals would be produced by it which would be transmitted in all directions through the water. Every vessel should also be provided with sound-receiving apparatus. For such a receiving apparatus it is proposed to employ some form of a telephone acting as a transmitter under water and connected with a receiver within the vessel. Such a transmitter must be protected against wind and waves. Wires from the transmitters would run to a small room protected from other wires, and could be fitted with ordinary telephones for use as usual. With such a contrivance Prof. Blake has carried on a system of signalling over one and-a-half miles in the Wabash River, using two boats, with an ordinary locomotive bell, around three windings in the river.

Tampering with Telegrams.—Harry Wilkes, a telegraphist, was on Tuesday charged on remand with wilfully and without authority altering and uttering telegrams at the Chief Telegraph Office, St. Martin's Lane. The allegations against the prisoner were that he had received a telegram from Sandown giving the names of horses about to start for certain races. Instead of despatching the telegram in due course to the Exchange Telegraph Company he detained it some minutes until the result of the race was known. He then despatched the former telegram, but altered the position of the winning horse as it was originally telegraphed. This was alleged to have been done for the benefit of persons betting, with whom the prisoner was acting in collusion. Prisoner was committed for trial.

Fools Rushing In.—Some curious facts came out before the Committee on Electrical Communication with Lightships. When it was known that the Trinity House was considering the question of connecting the *Sunk* lightship it was inundated with all sorts of schemes. Of the whole number Sir James Douglas computed that not more than 10 per cent. of them were feasible. A good many were simply ridiculous, and such as only a landsman would have thought of, while others, although sent in by eminent nautical men, were not practicable. Only three or four were deserving of notice.

Electric Light Plant.—Some valuable steam and gas engines, dynamos, lamps, and accessories will be for disposal at the close of the Liverpool Exhibition. Messrs. Holmes & Vaudrey having, according to rumour, made a good thing of their lighting contract for the two years the exhibition has been open, should be in a position to offer some genuine bargains, and the opportunity is a favourable one for acquiring machinery of a first-class kind at a low price.

A Miner's Electric Lamp in the States. — The *Electrical World* says it is probable that experiments will soon be made in the coal mines of the State of Pennsylvania, with a portable electric lamp possessing the following features: weight, about 3 lbs; illuminating power, five candles; size and shape similar to present lamps used in mines; duration of light, 10 hours; cost of repairs, charges of battery and material 2 cents for 10 hours.

Telegraphic Reforms.—At a special general meeting of the South of Scotland Chamber of Commerce it was agreed to support the following at the meetings of the Associated Chambers on September 27th and 28th :— To improve the foreign and colonial posting system, for the reduction of telephone charges, for a special low rate for night telegrams, and the revisal of submarine telegraph charges.

Electric Wire Casings.—Mr. Samuel Elliott, of Newbury, has just issued a book containing sections of 71 different forms of casings and covers for electric wires, many of the designs being new and registered. Mr. G. Annesley Grindle, of 19, Great Winchester Street, is the sole London agent for these goods.

Dissolution of Partnership.—Mr. A. P. Trotter informs us that he has dissolved partnership with Mr. Goolden.

Trade Catalogues.—The General Electric Apparatus Co. (proprietors, G. Binswanger & Co.), of 5, Great St. Thomas Apostle, E.C., has sent us its catalogues of electric light plant and material and electric bells, and as denoting the progress of electricity as a commercial undertaking these catalogues are a favourable augury for the future. We have gone through the catalogues and are struck on the one hand with their completeness in giving prices and descriptions of every conceivable apparatus which may be required in an electric light or electric bell installation, and on the other hand with the care with which any superficial or antiquated electric apparatus is omitted. The two catalogues contain about 90 4to pages, profusely illustrated, and amongst the articles which are mentioned therein we particularly notice complete descriptions of switches, cut-outs, instruments, and glassware. There is also complete reference to motive power, batteries, lamps, &c., and the electric bell list is exhaustive.

Admiralty Contracts.—The India-Rubber and Gutta-Percha Works Company have received an order for 60 search light projectors for the Navy.

Mr. Ronald Scott, of Hammersmith, has received orders from the Admiralty amounting to £3,000 for his patent switch boards, and other electrical fittings for the Navy.

To our Correspondents. — Correspondents must remember that we cannot insert their letters in the current week's issue when we do not receive them until Thursday morning. We have this week received too late for insertion letters on "Incandescent Lamp Patents," "Flickering in Arc Lamps," and "Insulation of Underground Wires;" these will appear next week.

A Large Storage Battery Plant.—Writing to the *Electrical World*, Mr. E. P. Roberts says :—"A plant of storage batteries in the Metropolitan Telephone Company's building in New York is stated to consist of 600 cells and to be the largest in the world. The size of the cells not being given I may be wrong in questioning thus the correctness of this statement, but we *now use*, here in Cheyenne, 310 cells of 50 ampère-hour capacity, and 434 cells of 100 ampère-hour capacity. In May, 1885 (as stated in my paper read before the American Institute of Electrical Engineers), we had 99 batteries of 21 cells each, or a total of 2,079 cells in operation. I also notice that different methods of connecting storage batteries with dynamos have recently been explained in this paper, and, therefore, I present diagrams of experiments tried in our works; although merely experiments, they were on a working scale. Our batteries, of the Brush system, are usually charged in series. The experiments were made with two 450-light dynamos and about 300 storage cells—the dynamos are compound wound Brush machines. The two dynamos run in multiple, and all the storage batteries in multiple also. The two dynamos 'in series' on three-wire system and the batteries likewise. We do not use either system, but found no trouble in doing so if desired."

Edison's Heat Generator Anticipated.—Correspondence in the *Electrical World* reveals the fact that Mr. Emile Berliner anticipated in substance the invention of Mr. Edison's most recent invention by more than two years, as in a specification filed on June 18th, 1885, he described what he termed the invention of certain new and useful improvements in electric furnace generators. The invention had for its purpose the production of electricity by the assistance of heat, and the following were stated to be the principles upon which it was based: "Iron, when heated to bright red, is not affected by magnetism, and in turn does not react upon that force; but if cooled down to a dull, red heat, it instantly regains the ability to absorb or engage magnetism. Furthermore, if a magnet is capable of holding suspended a mass of iron, *i.e.*, an iron armature weighing not more than, say, 20 pounds, it will also be capable of holding suspended on it a mass of brass, or other non-magnetic material weighing, say, 15 pounds, by means of an iron armature weighing only a fraction of an ounce. This shows that in order to engage, say, three-quarters of the attractive capacity of a magnet, a very small portion of the equivalent weight of iron is required to do this. It is also well known that the greater the amount of displacement of the magnetic field in a magneto-electric generator, the greater is the current produced in the conductor of said generator. If now I take a magnet and provide it with a coil around its pole or poles, and place before this magnet and in proximity to the coil a piece of iron heated to bright red, nothing will occur to disturb the magnetic field, but the instant the iron cools down to a dull red the magnetism becomes excited, and a momentary current of electricity is produced in the coil. I may go a step further, and have a series of such magnet coils and iron armatures, and by connecting the coils into the same circuit and cooling the armatures in rotation, one after the other, a number of electrical impulses will be produced which, when they follow one another rapidly, will approximate a continuous electric current."

Electric Lighting of Works and Factories.—Prof. J. A. Fleming, M.A., read a paper at the recent meeting of the Iron and Steel Institute at Manchester, on "Electric Lighting in Works and Factories." He said one of the questions which most frequently occurred with reference to mill and factory lighting was whether the factory engines could be used to run the dynamo. As a broad general rule, there could be no question that the best results were obtained by using a separate dynamo engine, controlled by a good governor set apart for that purpose. With the aid of a certain class of governor it was possible to drive a dynamo from a mill shaft providing the requisite power, but of which the speed of rotation was not sufficiently uniform to secure alone efficient regulation of electromotive force. Whatever might be the sanitary or incidental advantages of electric lighting, there was one essential condition of its adoption, viz., that it must benefit the pocket of the user on the whole. One of the great incidental advantages which the incandesecnt light possessed as an illuminant in workshops was that it could be suspended over lathes or tools, or in machines in positions which gas could not well be used or would be dangerous. It had been tried in cotton mills, and cleaner yarn produced. The health of the operatives had also benefited. In clean and dry mines scope was offered for fixed and permanent electric lighting. In the case of very deep shafts advantage might be gained in economy of conducting cords by the employment of a secondary generator system. Regarding the whole question of the electric illumination of mills, works and mills, it was with considerable confidence that he made the statement that the more closely its advantages and merits were inquired into the more forcible they would seem, even in the face of the fact that gas in the United Kingdom had a lower average price than in any other portion of the world. A short discussion followed, in which the opinions of Prof. Fleming met with a general acceptance.

British Association Grants.—The following grants have been made to its committees by the Association:—Electrical standards, £80; magnetic observation, £15; standards of light, £100; electrolysis, £50.

More Electric Locomotion in the States.—The new steel railway at Woonsocket, R. I., will soon substitute electricity for horse power. The over-head system has been adopted, and wires connecting with dynamos are extended 18 feet above and joined to the cars by wires which slide on the upper wires by means of rolling trolleys. The electric motors are placed under the floors of the cars, and they will be lighted by four incandescent lights of 20 candle-power each.

The Seel Glow Lamp.—This new lamp, which is the invention of Mr. Carl Seel, of Charlottenburg, is fast winning favour throughout the German Empire; in Berlin there are several theatres and restaurants lighted by the new lamp, which is of low resistance, and made upon an entirely new principle. The filaments, which are of two kinds, are prepared from leather and silk threads, coated with a mineral substance and paraffined. The lamp has recently been the subject of litigation in Germany, but the patent has been held valid in the German Patent Office. The Great Seal has been granted to Mr. Seel, both in Germany and the United States of America, strong evidence that the lamp is free from infringement. The patents are owned by the Actien Gesellschaft für Electrische Glühlampen, of Berlin, which already employs about 60 hands. The company is extending the works in order to meet the demand for its lamps, which it is said already exceeds 3,000 per week.

Mexican Telegraphs.—Some time ago we had occasion to notice the energy displayed by the new Director-General of Mexican Telegraphs, Senor Yslas, in reforming the telegraph system. In 1884 the distribution of wires was as follows:—

Federal Government lines	21,000	kilometres.
States	1,653	,,
Railway	4,430	,,
Private	3,301	,,
Submarine cables	703	,,
	32,087	,,

5,200 kilometres with 97 offices have been handed over to the States as being unproductive to the Federal Government. On the remainder of the system new instruments have been substituted for old forms; 11,000 kilometres of line have been repaired and placed in working order, and 1,675 kilometres of new lines have been constructed.

Electric Lighting in Bolivia.—A large arc and incandescent plant is being shipped by the United States Electric Lighting Company to the City of La Paz, Bolivia. The plant includes two 225-light incandescent machines for street lighting, two 500-light incandescent machines for commercial purposes, and a 10-light arc machine for park lighting. Mr. D. E. Drake, the manager of the engineering department of the company, planned the whole plant, which can be worked either by water or steam power. Water for motive power purposes can be obtained for nearly nine months in the year, but coal is so expensive that manure is mainly used as fuel. La Paz has a population of about 70,000.

Obituary.—It is with much regret, but with little surprise, that we hear, just as we are going to press, of the death of Mr. O. E. Woodhouse, senior partner of the firm of Woodhouse & Rawson, engineers and electric light contractors. Mr. Woodhouse, whose premature death has doubtless been accelerated by overwork and the worry consequent upon the preparation for the recent litigation respecting incandescent lamp patents, has been for the past two years unable to attend to business; his loss will doubtless be keenly felt amongst his large circle of friends in the electrical world.

The Telephone Companies and the Government.—With the September issue of his "Monthly Investment List" Mr. F. Faithfull Begg, of the London Stock Exchange, gives a memorandum showing particulars of the capital of the principal telephone companies and the latest price of the shares. Commenting on the subject, he says :—"There is here a little group of investments which will well repay a little attention. The general public seems nearly as heedless of the merits of these shares as the Post Office Department itself seems to be ignorant of the position and future of the telephone industry. In reply to a question in the House of Commons, the Postmaster-General a few days ago (speaking, of course, as the mouthpiece of the permanent officials), exhibited a want of knowledge and appreciation which would be ludicrous if it were not shocking. Speaking of long-distance telephony, he said, *inter alia*, that he 'belived' it was in existence between Manchester and Liverpool, and went on to add, that he was inclined to doubt whether there would be much public advantage in establishing telephonic communication generally between towns at a distance. Now anyone who knows anything of the subject at all, knows that the Manchester-Liverpool line has been a marked success, and that not one wire between the two towns, but many are now in daily use. There is also a longer line, namely, that between Edinburgh and Glasgow, which was in operation before the Manchester-Liverpool circuit, and though now replaced by a private line, was originally erected by the Post Office itself! The simple fact about this matter is, that departmental jealousy of the success of the private companies has become more and more intense as it has become clear that red tape and bungling could make no headway against private enterprise. At every point throughout the kingdom, the Post Office has, from the beginning, used every effort to crush the companies. No single individual connected with the department, except the late Mr. Fawcett, has ever taken up other than the most obstructive and hostile attitude towards them, with the result that we are here to-day, in this country behind nearly every other nation of importance in the development of telepnonic facilities. If the public would take a little more interest in the matter something might be done ; the moment they do so, a marked improvement in all the shares mentioned in the enclosed list may at once be looked for."

Electric Lighting in New York City.—The New York City gas commissioner has awarded the following contracts for lighting the streets and avenues of the city of New York with the electric light :—To the United States Illuminating Company, 53 lights, 15 at 24 cents each and the remainder at 40 cents each ; Brush Electric Company, 122 lights, 53 at 22 cents each, 46 at 25 cents, and 23 at 40 cents ; East River Electric Company, 445 lights, 354 at $19\frac{9}{10}$ cents and the remainder at 39 cents ; Mount Morris Electric Company, 15 lights at 40 cents apiece; Harlem Electric Company, 135 lights, 116 at 24 cents, 12 at 50 cents, and 7 at 60 cents ; American Electric Manufacturing Company, 93 lights at 32 cents ; North New York Electric Light Company, 26 lights at 40 cents each.

Manual Training.—At Manchester, Mr. W. Mather, M.Inst.C.E., read a very interesting paper before the Economic Science and Statistics Section of the British Association, advocating the training of the hand as a main feature in national education ; in other words, that there should be in our public elementary schools a constant and systematic co-operation of the hands with the brain as the means of learning. He stated that as an employer his experience had convinced him that the present method of teaching, "admirable as it is in giving a higher tone to our working classes, and in developing considerable literary power, yet in the main is one-sided in its effect even on a really gifted boy, while it does nothing to call forth the practical faculties in boys who, slow and even stupid in the class-room, may possess considerable aptitude in acquiring knowledge after they have begun to work for a living ;" the advantages that would be gained by an improvement of the present system in this direction were stated to be "the enhanced happiness of children during their school life, the elevation and refinement of the working classes of the future, and the moral, material and mental enrichment of the nation."

Petroleum.—A little book has been published (at 402, Strand, London) under the title of "Petroleum : valuable hints to those who use it," which contains a mass of information on a subject of considerable popular interest. Its domestic uses are fully dealt with, whether the purpose be lighting, warming, or cooking, but the subject of its substitution for coal in steam engines is not entered upon. The statistics given of the petroleum industry are rather startling ; for instance, the total world's consumption of mineral lamp oil is stated to be more than 2,000,000 gallons per diem, and to be still growing, notwithstanding the improvements effected in other means of illumination. An idea of the magnitude of the trade in America may be formed from the statement that a single oil barrel factory there turns out 12,000 finished barrels per day. Amongst the many valuable hints which are given as to management of lamps, the one most insisted upon is to keep them scrupulously clean, most of the defects generally complained of by users being traceable to a neglect of this first rule.

An Efficient Accumulator.—Writing to the *Engineer* from Sydney, Mr. W. T. de L. Roberts says :—"I have been experimenting with electric accumulators, and wishing to have a more efficient one than I could buy, I made two cells which were a slight modification of the 'Plante' and 'Union battery' combined, which gives—to me—a wonderful result. I have one pair of plates only 4 inches by 4 inches for each cell, and having connected them in quantity with my other accumulators, worked them up together for some weeks, every evening running them partially down to light the house. When I considered the new cells ought to be worked up, after charging them for a day I disconnected from the main and connected in series with a 5-volt lamp to test the capacity. After burning for three hours I was compelled to leave it, so I disconnected for the night without recharging and lit up again next morning. The whole of that day it remained burning, so I was again compelled to disconnect for the night. The next evening I lit up again, and so on every evening for two, three, or four hours until I had obtained over 35 hours work from the two cells, extending over 11 days. After that the lamp would not burn for more than one hour at a time without getting duller, but seemed to recover itself after a few hours' rest, losing from 12 to 14 minutes in duration regularly each day. Now, I am not aware that either the 'Plante' or 'Union battery' will give anything approaching this result ; perhaps some of your readers can tell me if such a result has ever been obtained. The loss of 12 to 14 minutes a day must principally be due to leakage, because I had taken no special care on that point, and my old accumulators placed in the same position would be nearly emptied through leakage alone in 10 or 12 days."

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Manchester and District Edison Electric Light Company, Limited.—The annual return of this company, made up to the 5th inst., was filed on the 12th inst. The nominal capital is £600,000, divided into 50,000 A and 10,000 B shares of £10 each. The shares taken up are 20,000 A and 10,000 B, and upon the former £2 per share has been called up and the full amount upon the latter. The calls paid amount to £140,000.

Sudworth and Company, Limited.—The registered office of this company is at Falcon Works, Bentham Road, South Hackney.

Anglo-American Brush Electric Light Corporation, Limited.—An agreement of 14th inst., filed on the 16th inst., between this company and the International Electric Company, Limited, and its liquidator, Mr. Ernest Cooper, of 14, George Street, Mansion House, provides for the purchase by the Anglo-American Company of the assets of the International Company, the former company to issue one fully paid share of £5 in respect of every 20 shares held in the latter company upon which not less than £4 has been paid, and fractional certificates for any number of shares less than 20. The agreement provides for the allotment of 1,264 shares and 588 /20 fractional certificates.

CITY NOTES.

Direct Spanish Telegraph Company, Limited.—The directors' report just issued states that the accounts for the half-year ended June 30th, 1887, show, after providing for debenture interest and a charge for renewal referred to in paragraph 5, a balance to the credit of profit and loss of £4,649 10s. 3d. The traffic receipts show an increase of £366 19s. 9d. as compared with the corresponding half-year of 1886, when a higher rate of tariff existed than at present. The directors have, in accordance with the policy announced when the reduction of capital was agreed to by the shareholders, put £2,500 of the balance of profit and loss to the reserve fund, which now amounts to £5,899 8s. 3d., and there will then remain £2,149 10s. 3d. available for dividends. The directors recommend the payment of the dividend of 10 per cent. on the preference shares, and a dividend at the rate of 2½ per cent. on the ordinary shares, free of income tax, and to carry forward £2 19s. 3d. to next account.

TRAFFIC RECEIPTS.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 15th September are £1,989, as compared with £1,864 in the corresponding period of 1886.

NEW PATENTS—1887.

12511. "Magneto machines." T. F. WALKER, J. G. W. FAIRBAIRN. Dated September 15.

12514. "Telegraph apparatus for ships and mines and other purposes." F. R. FRANCIS. Dated September 15.

12516. "Interrupter for electric circuits." I. E. LECOULTRE. Dated September 15.

12528. "Secondary batteries." I. A. TIMMIS. Dated September 15.

12542. "Electrical storage batteries." T. C. LEWIS. Dated September 15.

12585. "Covering telegraph cables." A. WYLIE. Dated September 16.

12635. "Electricity meters." W. LOWRIE, C. J. HALL. Dated September 17.

12636. "Dissipating electricity for printing presses." L. E. BATHRICK. Dated September 17. (*Complete.*)

12645. "Carrying electrical batteries for driving tramway vehicles, &c." W. D. SANDWELL. Dated September 17.

12676. "Dynamo-electric generators." W. T. GOOLDEN, L. B. ATKINSON. Dated September 19.

12683. "Making spongy lead for electrical accumulators." F. M. A. LAURENT-CELY. Dated September 19.

12697. "Regulating electric currents, &c." F. V. MAQUAIRE. Dated September 19.

12718. "Electrical speed indicators." J. TAIT. Dated September 20.

12763. "Electric meters." G. FORBES. Dated September 20.

12786. "Fittings for incandescent electric lamps." S. SUDWORTH, C. K. FALKENSTEIN. Dated April 21.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1886.

9793. "Improvements in glass globes or shades and holders for incandescent electric lamps." H. LEA. Dated July 29. 8d. Claims:—1. The construction for use in connection with an incandescent electric lamp of an ellipsoidal glass globe with a circular aperture and notches in combination with a disc cover wholly or partially transparent, having suitable projections and a clip, for the purposes hereinbefore described and illustrated in the drawings. 2. The formation of a circular aperture having notches in a shade of glass, or other transparent or semi-transparent material, or in a glass globe of any other shape than ellipsoidal, so that the said shade or globe may be used in combination with the disc cover and disc, described and illustrated in the drawings. 3. The modification in which a projecting lip on the globe, having flats formed on it, is used in combination with projections formed on a metallic rim affixed to the disc cover, for the purpose described and illustrated in the drawings. The various devices referred to in the preceding claims, in combination with globes, having the arrangement of belts or zones of clear ground and cut glass, as and for the purpose described and illustrated in the drawings. 5. The general construction, combination, and arrangement of parts of globes and attachments for incandescent electric lamps, hereinbefore described and illustrated in the drawings.

9854. "Improvements in telephonic apparatus." D. BOYD and S. WILLIAMS. Dated July 30. 8d. Claims:—1. A telephone transmitter wherein the tension regulator consists of pieces of carbon or other suitable material suspended or supported in loose contact by means of metal rods or wires, substantially as described, to be acted upon by the sound waves or voice vibrations without the intervention of a diaphragm, tympan, speaking-tube, soundboard, or the like. 2. The improved telephone transmitter constructed substantially as described with reference to the drawings, and operating as specified. 3. The peculiar method or manner of coupling up or connecting the transmitter and receiver or receivers, the primary circuit or circuits of one or more induction coils, a battery or batteries and the line wire or main circuit, substantially as and for the purposes set forth.

9991. "Improvements in electric batteries." H. ARON. Dated August 4. 6d. Claims:—1. The application in an electric battery of oxide of mercury in an insoluble state as a depolarising agent with the positive pole, in combination with zinc and an alkali forming the negative pole. 2. In electric batteries having a solid, insoluble depolarising agent at the positive pole as oxide of mercury, and zinc in an alkali for the negative pole, the application and combination of a coat or cover of fibrous material, particularly of wad, surrounding the zinc and serving to prevent any heterogeneous matters floating within the fluid from coming into contact with the zinc, which coat or cover may also serve to soak up the fluid of the pile and diminish its volubility, substantially as and for the purpose described.

10393. "Improvements in the methods of constructing conduits, ways, or cases for electrical conductors and analogous purposes." T. O. CALLENDER and C. E. WEBBER. Dated August 13. 6d. The receptacles or cases are provided with one or more separate ways of suitable diameter in proportion to that of the insulated electrical conductor, one for each such conductor. These cases may be constructed as follows:—The moulds are simply rectangular or triangular cases, consisting of a strong bed or bottom plate of wood or iron with two sides hinged thereon to be held in position by clamps or otherwise. These moulds should be further provided with movable end or face plates made in sections according to the number of layers or tiers of ways to be made in the case. These moulds are placed on the ground lengthwise and the case is built up therein. In making the case it is found expedient to have the lowest section of the end or face plate hereinbefore referred to of a height equal to the minimum thickness of the material in the case generally. It consists simply of a strip of suitable iron with an arrangement for its being properly held in position and on its being fixed, bitumen concrete in a molten form is run in and stamped with heated irons to consolidate it. On the top of the lower section of end or face plate the section perforated to carry the dies for the ways is fitted but before it is placed in position, the dye rods suitably covered with paper or other material of a nature to facilitate their withdrawal are placed in the holes provided for their reception, so that the form for the production of the ways is dropped into its place complete. When so placed bitumen concrete is run in and likewise consolidated with hot irons. This operation of filling in being continued until the way dies are covered to the depth of half an inch or more as may be required when stamped and consolidated. Subsequent tiers of ways may be formed in the same manner, a separate end plate with its die rods placed in position being used for each tier. The upper part of the case may be finished off by being smoothed with a suitable heated iron. The case is then allowed to set and harden, but before this is completed we withdraw the die rods for the ways, still leaving the end or face plates in position. Claims:—1. The construction of conduits, ways, or cases for electrical conductors, lines, cables, or the like, substantially as described, with a separate way therein for each conductor, line, or cable. 2. The construction of conduits, ways, or cases for electrical conductors, lines, cables, or the like in the manners or according to the methods described.

CORRESPONDENCE.

Telephones not Patented.

I note in your valuable REVIEW of the 9th inst. a reply by Mr. Barney to my letter of the 29th July. I shall now reply to his remarks *seriatim*, as I am a *little struck* by them.

Mr. Barney starts by taking me to task for maintaining that it was the "English Mechanic" telephone that brought about Bell's disclaimer. Now when that statement was made I partly proved it also, and still hold I am correct.

I shall, however, now clinch the matter beyond doubt by unquestionable proof. But just before doing so let us turn aside for a little and observe the way Mr. Barney pretends to show my assertion to be wrong. "Sirs," with the knowledge I know you to have on the subject, Mr. Barney's statements must at the least cause you to smile. Candidly, I confess, they made me laugh loud and long. But to continue. With a sledge hammer stroke I am informed "that the owner of a patent cannot disclaim anything not in the patent."

Who said he could? But if Mr. Barney were to just read the 9th December, 1876, patent, with its 18 claiming clauses, he would see that every conceivable form of telephone worked with the undulatory current is there most distinctly claimed, including, of course, the E.M.T.

Mr. Barney next says:—"The disclaimer *was necessitated* by the publication of the claims and drawings of Bell's U.S. patent of March 7th, 1876, published in the Official Gazette of the United States Patent Office on March 7th, 1876, and *on file* in the British Patent Office, *July 3rd*, 1876."

Now as to the first part of this paragraph I have no knowledge on American patents; but, for certain reasons, I should have imagined Bell's patent for his receiver was not filed till *somewhat later* than March 7th, 1876, in the U.S. This, of course, I do not pretend to know; but, "Sirs," it is the latter clause, relating to the filing in the British Patent Office, that comes to me as a revelation. Why, such a claim on July 3rd, 1876, is not to be found in the records of the British Patent Office. I am afraid it exists only in the imagination of your valued correspondent. But I am spell-bound with amazement at Mr. Barney's next declaration. "Listen." "Now the disclaimer was for the cone having a membrane stretched over one end with one end of an armature attached to its centre, the other end attached to the uncovered leg of an electro-magnet, represented in fig. 19 of Bell's English patent."

Really, Mr. Barney, this is excruciatingly funny. Why, Sirs, at the end of "Bell's disclaimer and memorandum of alteration" the last words are: "And the said specification when so disclaimed, altered, and amended, will read as follows."

And what follows? Why, a most particular description, *inter alia*, of the instrument Mr. Barney says constituted the disclaimer. I will spare Mr. Barney any further comment, and simply ask, what, then, was the disclaimer for? I maintain that the disclaimer filed by Bell on 13th February, 1878, was on account of the E.M.T., and this reminds me, I must redeem my promise made near the commencement of my letter. So I will briefly prove this. Let me do this by going to the amended specification. What do we read there?

"And it is to be noted that no claim is made to the use of telephonic apparatus wherein a membrane like *goldbeater's skin* is used in combination with an electro-magnet excited by a battery which is arranged in the main circuit or line wire, inasmuch as such a membrane *was mentioned in descriptions published in England prior to December 9th*, 1876, &c. . . ."

I could furnish Mr. Barney with still more evidence, but surely this should suffice. Now, can't anyone see that the E.M.T. is here alluded to? For hadn't that instrument a goldbeater's skin diaphragm and the circuit arranged exactly as here described?

But, to put the matter quite at rest, what was the *only* instrument of this kind and worked in this way *described and published prior* to 9th December, 1876, the date of the Bell patent in England? The answer is, of course, the E.M.T. published here in August, 1876. If there had been such a thing as Mr. Barney's visionary July 3rd, 1876 patent, there would have been no E.M.T. free to the public. *En passant*, let me here say that I hope at a future date to prove by the Bell specifications that there is not the slightest risk of infringement of the Bell telephone by anyone who attaches an armature, *under certain conditions*, to a diaphragm which in itself is not capable of inductive action upon a current of electricity.

I will take the liberty of continuing this letter in your next publication.

J. S. Ross.

September 21st, 1887.

Carbons for Arc Lamps.

Your correspondent, Mr. Lever, illustrates the relative cost of employing cored carbons or plain American carbons by giving the working expenses of two lamps using 12 mm. rods. The cored rod he takes at 4d. per foot which is over 100 per cent. dearer than the list price of my company's make including free delivery from their works. It is true that cored rods equal in quality to those imported were not manufactured in this country until the beginning of this year, but at the present time I think the "home made" carbon is superior, and I shall be very pleased to send some cored carbons of various diameters for Mr. Lever's valued opinion.

Charles H. Cathcart.
GLOBE ELECTRICAL & ENGINEERING CO.

September 21st., 1887.

An Explanation Necessary.

I have just returned from Vienna, and read your remarks in your number of September 9th regarding the prospectus of the Water Primary Battery Company. For some time past I have been constantly meeting Mr. D. Monnier, who is the consulting electrical engineer to the Imperial and Continental Gas Association. He asked me to let you know that a D'Humy cell was sent to him to be tested some years ago at his Paris laboratory, but that he never made any report on it or expressed any opinion for or against it, and that his name has been made use of in a most unwarrantable manner.

R. E. Crompton.

September 16th, 1887.

[Mr. Crompton has done good service by sending us this letter, which we hope will come under the notice of those rhapsodists who represent the science of the daily press.—EDS. ELEC. REV.]

A New Outdoor Light.

Your readers may have noticed in the columns of the daily press an old method of illumination described under the above heading. The light is produced by forcing an air-jet through crude oil, which is thereby transformed into spray, producing when lighted a brilliant flame. To this illuminant the name of Lucigen has been given, but it may interest your readers to know that, notwithstanding the claim of novelty put forward, the system has been in full blast for 20 years. In the foundry of the ironworks where my apprenticeship was served this identical method of lighting was adopted, the air-jet in the case referred to being supplied from the cupola fan. So much for the "new" light.

W. B. Esson.

September 17th, 1887.

Magnetic Permeability of Iron.

Mr. Trotter's letter (ELECTRICAL REVIEW, September 16th, page 503) refers to a British Association paper by Mr. Low and myself which has not yet appeared in your columns. I explained at the meeting that we had calculated the thickness of air space that would give a magnetic resistance equal to that of the joint between the halves of a cut iron bar, and had

found it to be only about $\frac{1}{35}$th of a millimetre, or, say $\frac{1}{900}$th of an inch. This thickness of air corresponds to less than 1 inch of iron. Mr. Trotter puts the resistance of a joint as equivalent to 8 inches of iron or $\frac{1}{90}$th of an inch of air, that is, ten times what it was in our bars. On what experiments is this estimate based? Our experiments give strong evidence that the magnetic resistance of a joint is due to a film of air, by showing, first, how thin a film is sufficient to account for the observed resistance, and, second, that the resistance vanishes when the surfaces are pressed together with considerable force, provided the surfaces are truly plane.

Allow me to take this opportunity of correcting an error in the report of my remarks on Mr. Preece's paper (page 291). The figure quoted as the calculated ratio of self-induction in two telegraph circuits of specified form, one of very soft iron strongly vibrated, and the other of non-magnetic wire, was 20,000 to 1, not 1,000 to 1.

J. A. Ewing.

September 19th, 1887.

The Causes of Unsteadiness in Arc Lamps.

Since I have simply taken Mr. Swinburne's thesis too literally, the subject evidently does not admit of further discussion; read as that gentleman has intended it, the passage in question is equivalent to my remark that all lamps give a better light with good carbons than with bad.

I observe that Mr. Swinburne touches upon a point which the length of my former letter had constrained me to leave unnoticed, viz., the effect which has received amongst English-speaking electricians the far from elegant and by no means euphonious designation of "pumping." Mindful of this disagreeable phenomenon, I mentioned the Foucault-Duboscq and Gatehouse-Kempe lamps as types of the ideal regulator, without, be it understood, advocating the employment, at least of the former, in practical every-day installations. The ideal lamp would not necessarily be the best from the point of view of its practical use, and although a good lamp should not "pump" a double movement is a rather too complicated way of obviating this disadvantage. The "dash pot" (other cacophonous and technical terms) is usually the refuge of the luckless inventor whose lamp manifests too utterly erratic tendencies, and although Mr. Swinburne admits that the "dash pot" is by no means all that could be desired, and seems to consider it as doubtful whether or no the remedy may not be worse than the disease, still cherishes an affection for the vicious makeshift in question. The opinions of electricians on this subject are various. Personally, I do not admire the "dash pot," and will stick to my opinions even though I may be "potted at" by each and every inventor who has pinned his faith to an oil or glycerine filled cylinder! Moreover, the "dash pot" is not required for the controlling coil if the arc is "struck" by a separate thick wire magnet as in the Crompton lamp mentioned by Mr. Swinburne, and also in those of Gramme, Grovin, Breguet, Abdank-Abakanowicz, Newton, Sellon, and others. This construction is evidently by far the most rational, since the "pumping" effect is done away with and the regulating coil must obviously work better and permit of a more delicate adjustment of the arc-length than in those lamps in which the same coils serve both for forming and regulating the arc. The feed should be controlled by a shunt magnet or solenoid as the self induction of the long helix of fine wire diminishes the effect of momentary variations of the current upon its attractive force. For the regulation a solenoid is inferior to a magnet on account of its far more equable action, but when employed for "striking" the arc gives unsatisfactory results through its constant tendency to "pump."

I recollect an attempt once made by me to work an arc lamp upon a Gramme machine driven by an irregularly-working motor. The arc length was controlled by a pair of thick wire solenoids; of course the oscillations of the cores of the latter corresponded with the speed variations, and the result was simply frightful, every piston stroke being visible in the arc. The lamp was at once discarded and replaced by a regulator constructed with a magnet drawing down the lower carbon to a fixed distance. This changed at once the state of things, for, although the swing of the ampère needle indicated a considerable variation of the current intensity the arc remained admirably steady. Evidently this is an extreme case, since in the generality of instances the engine works well, but the same effects are always manifested whenever a variation of the current strength occurs, and obviously the impurities and gases contained in the carbons and the shifting of the arc upon the points are the principal causes of sudden changes of the arc resistance. The steadiness of *la Lampe Soliel*, which was to a certain extent independent of fluctuations of the current, is probably to be attributed to the fixity of the electrodes, at least as much as to the incandescence of the marble block. It must be allowed that the separate arc striking magnet, although so advantageous in many respects, has, unfortunately, a great defect, since it augments the chances of a "break down" if the lamps are driven by a series dynamo; thus, supposing a momentary interruption of the current to occur, and that the magnet in letting go its armature does not re-establish the contact between the points, the machine will be unable to send a current through the high resistance shunt coils, and a "break down" results.

To avoid similar accidents I have generally employed a thick wire "cut-out" which throws a resistance into the circuit in place of the extinguished arc.

Another method used in the Sellon arc lamps, and applied, if I remember rightly, for the first time in the "Pilsen," consists in winding a helix of thick wire upon the shunt coil. The said helix being thrown into circuit by the cut-out, draws down the armature, thus releasing the carrier and allowing the carbons to come into contact.

In the Breguet lamp a rod attached to the armature of the arc striking magnet engaging with that of the shunt coils when the former is released lifts the pawl controlling the star-wheel, and allows the carrier to fall.

A most ingenious form of magnet is that invented by M. Abdank-Abakanowicz. The core of this magnet, which is attached to the carbon carrier, is hollow, and contains a movable rod bearing the upper carbon. The armature acts like a ring clutch when attracted, and gripping the above-mentioned rod lifts it with the carbon, and forms the arc. Should the current cease to pass the armature is released, and allows the carbon to fall until contact is established between the points, whereupon it is once more lifted and the arc again struck.

Of all these methods this latter is probably the best, but, of course, this is a matter of opinion. If the partizans of the arc striking magnet are few, still fewer must be the admirers of perhaps the best known of its forms.

My personal experience in these matters has disposed me to consider that, supposing a double movement to be inadmissible, the next best thing is certainly a lamp constructed with a separate arc striking magnet. But if this arrangement be employed the feed ought to be decidedly slow, and the lamp easily adjustable and well adjusted, since in case of over-feeding even a partial automatic readjustment of the arc length is impossible.

For the reason that my letter is already long I defer my reply to Mr. Charles Lever until next week.

I will, however, crave an additional few lines to point out that the "printer's devil" has rendered the closing passage of the second paragraph of my letter somewhat ungrammatical; that the first word of the Latin quotation has been by him mis-spelt, and that I never wrote of "fits" but of "jets" of gas emanating from the carbons.

F. de Wolffers.